April 1975

Flood Damage:
Pajaro River Basin

S-5

Santa Clara Valley Water District

South Santa Clara Valley
Water Conservation District

TC
425
P35.F56
1975

4551

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Flood Damage: Pajaro River Basin for SCVWD & SSCVWCD April 1975. Anderson-Nichols & Dr. Andrew H Trice

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Flood Damage: Pajaro River
Basin for SCVWD & SSCVWCD.
April, 1975
Anderson-Nichols and Dr.
Andrew H. Trice

PROPERTY OF SANTA CLARA VALLEY
WATER DISTRICT
5750 Almaden Expressway
San Jose, California 95118

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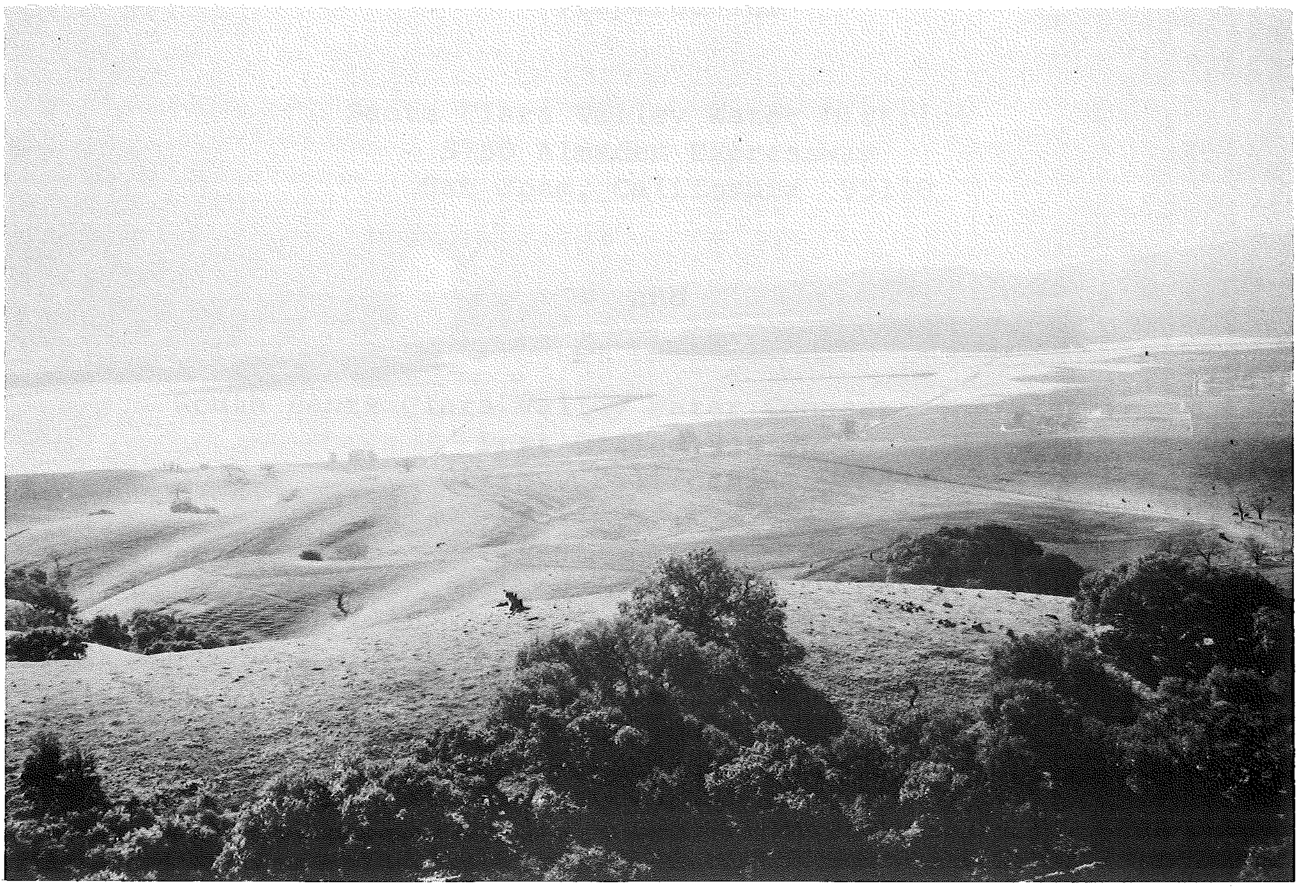

SOAP LAKE-FEBRUARY 1969 FLOOD
(Looking westerly toward Pajaro River at Sargent)

TC425P35 F56 1975

FLOOD DAMAGE - PAJARO RIVER BASIN

RESERVOIR SYSTEMS STUDY

Prepared for

Santa Clara Valley Water District
5750 Almaden Expressway
San Jose, California 95118

and

South Santa Clara Valley Water Conservation District
Post Office Box 366
Gilroy, California 95020

Prepared by

Anderson-Nichols & Co., Inc.
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April 1975

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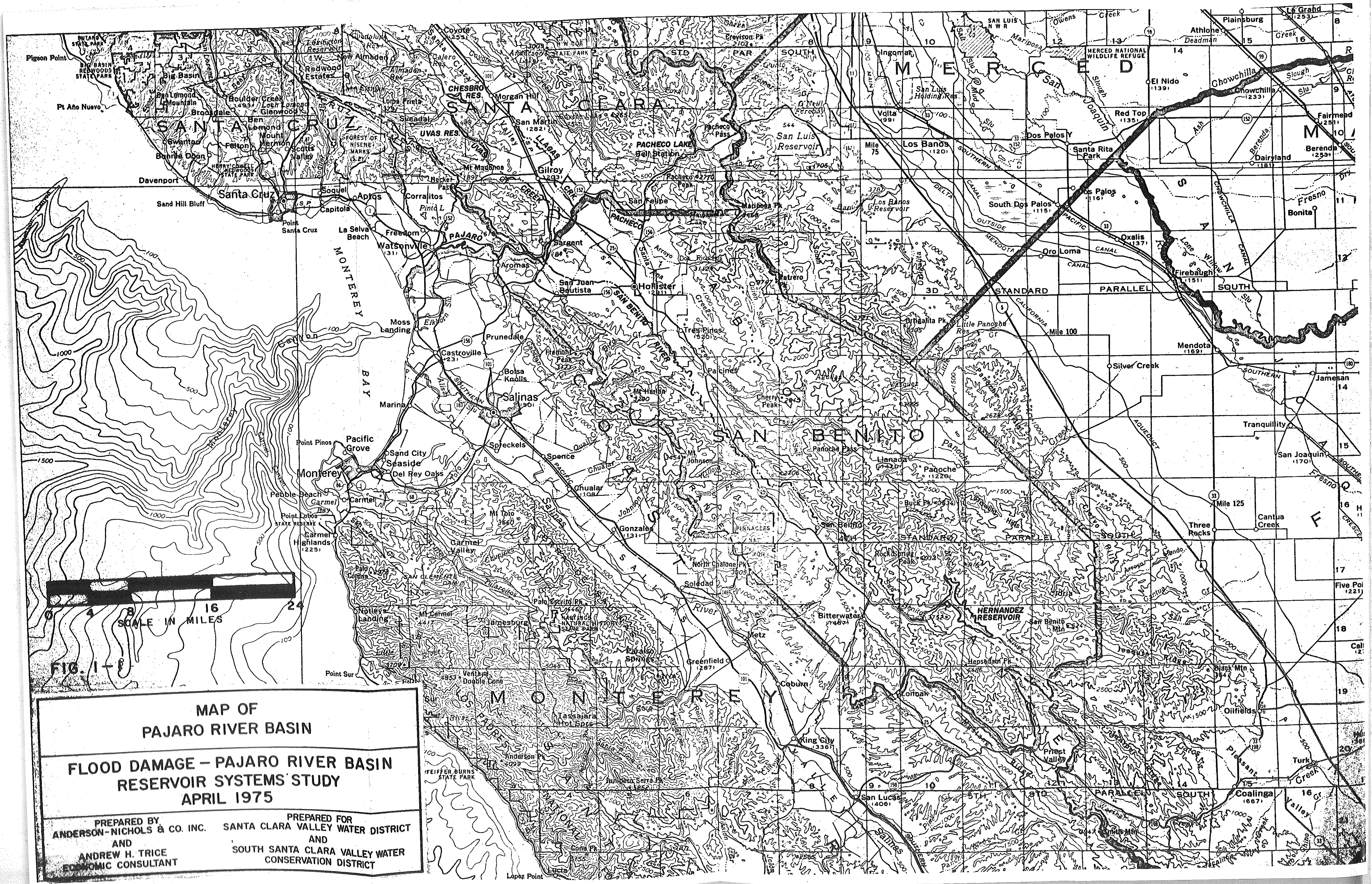

FIG. 1-8

MAP OF PAJARO RIVER BASIN

FLOOD DAMAGE – PAJARO RIVER BASIN RESERVOIR SYSTEMS STUDY

APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO. INC.
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ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT

SECTION 1

INTRODUCTION AND SUMMARY

This report presents the results of an investigation of flood damage in the Pajaro River Basin, California, including an evaluation of existing reservoirs plus the proposed Hayes Valley Reservoir for flood control operation of Uvas-Carnadero Creek for the purpose of reducing flood damages. Other purposes such as conservation, recreation and anadromous fishery enhancement are proposed for the offstream storage reservoir at Hayes Valley but these purposes are not considered in this study. A map of the Pajaro River Basin is shown in Figure 1-1

The work was performed under contract to the Santa Clara Valley Water District, 5750 Almaden Expressway, San Jose, California 95118, by Anderson-Nichols & Co., Inc., Boston, Massachusetts; Project Manager Dr. Anthony H. Slocum, 2920 San Ysidro Way, Santa Clara, California 95051. Economic evaluation was performed by Dr. Andrew H. Trice, Economic Consultant, 140 Loma Linda Court, Scotts Valley, California 95066, under contract to South Santa Clara Valley Water Conservation District, P. O. Box 336, Gilroy, California 95020. This report presents combined results from these two contracts.

The study has three primary objectives: 1) To ascertain potential damages due to floods in the agricultural and urban areas comprising the Uvas-Carnadero Basin of the South Santa

Clara Valley; 2) to perform a detailed evaluation of potential flood control benefits in areas adjacent to Uvas-Carnadero Creek due to the flood control operation of proposed Hayes Valley Reservoir in conjunction with the existing Uvas and Chesbro reservoirs; and 3) to evaluate potential benefits in the Lower Pajaro River Basin near Watsonville, California, due to the flood control operation of existing reservoirs plus proposed Hayes Valley Reservoir in the Upper Pajaro River Basin.

APPROACH

This is a supplementary study to previous work performed by the Corps of Engineers, San Francisco District, Santa Clara County, Santa Clara Valley Water District, and South Santa Clara Valley Water Conservation District. A majority of data was obtained from these sources. Computer simulation was used extensively in order to achieve the project objectives in the short time span which was available. The primary analysis was performed using a computer program, HEC-5C, Simulation of Flood Control and Conservation Systems, developed by Bill Eichert, Director, The Hydrologic Engineering Center (HEC), Corps of Engineers, Davis, California. A model of the entire Pajaro River Basin was developed using HEC-5C which provided the capability to perform various flood routings with alternative reservoir configurations and operation in order to evaluate the flood control impact at key locations within the basin. Water surface profiles were also developed along the Uvas-Carnadero Creek for various flow rates using the computer program HEC-2, Water Surface Profiles. The results of these simulation runs were used to locate areas along the levees near Gilroy, California, where overtopping is most likely to occur with potential levee failure. The results also provided the basic information used to delineate flooded areas which could be expected for various levels of flood flows. The HEC Gradually Varied Unsteady Flow Profiles computer program was used to perform an approximate analysis of levee overtopping and failure to define a velocity field and corresponding depths which could be expected in areas adjacent to the levee failure.

SUMMARY OF RESULTS

A detailed description of hydrology and hydraulic analysis procedures, assumptions and results is contained in Section 2 and a detailed description of the economic analysis is contained in Section 3. This subsection summarizes the principal results for each of the three above-stated objectives.

UVAS-CARNADERO DAMAGE EVALUATION

The expected average annual damage reduction (flood control benefit) which can be credited to the proposed Hayes Valley Reservoir was calculated from different damage information sources in order to evaluate the relative impact upon the total flood control benefit for Hayes Valley Reservoir. These results summarize findings for damage occurring due to overbank flood flows from the Uvas-Carnadero Creek.

Average annual damage calculations were performed using the HEC-5C model for three different sets of discharge-damage data. The initial computations were based on the damage data, termed Current 1975 Corps, recently developed by the San Francisco District Corps of Engineers during their evaluation of the Hayes Valley Reservoir, and other flood protection works on the Uvas-Carnadero. Using these data the HEC-5C model produced average annual damage, and damage reduction values which were smaller than those obtained by the Corps. This is attributed to the increased accuracy for local flow contribution and average annual damage integration routine provided by HEC-5C. The second set of damage data, termed Historic Flood Damage ('75), was based upon historic events from information appearing in the San Francisco District Corps of Engineers Review Report, _Flood Control and Allied Purposes Pajaro River Basin California_, dated April 1965. Damages experienced in the 1955 ($954,000), 1958 ($528,000), and 1963 ($241,000) floods for two reaches of the Uvas-Carnadero were escalated to 1975 dollars in order to develop a discharge-damage curve based on historical damages experienced in the Uvas-Carnadero area. It should be noted that if the damage experienced in the additional two reaches encompassing Soap Lake are included the actual damage (_in prices at the time of flood_) would total $1.8 million, $900,000 and $250,000 respectively for the 1955, 1958 and 1963 floods. Nonetheless the damage discharge curve based on the two reaches produced significantly higher average damage values and a comparison of this curve with the current 1975 Corps discharge-damage curve for the Uvas-Carnadero floodplain shows significant differences. The average annual damage reduction values calculated from the Historical Flood Damage ('75) are twice the levels computed by the Current 1975 Corps curve. For this reason a detailed analysis of the hydrology and economic data used for the Uvas-Carnadero evaluation was performed. Floodplain delineation based upon HEC-2 multiple water surface profiles together with new values for damage per acre were developed for various types of land use, both agricultural and nonagricultural. Details of the revised hydrology and economics are described in Section 2 and Section 3 respectively. A third set of discharge-damage data termed Revised Hydrology and Economic Data was developed as a result of this analysis. This also produced significantly higher average annual damage and damage reduction values.

A comparison of these discharge-damage curves is provided in Figure 1-2. These curves represent the total damage (1975 dollars) which would occur in the Uvas-Carnadero Creek floodplain if the given peak discharge was experienced in Uvas-Carnadero Creek at U.S. Highway 101. Curve I represents the Current 1975 Corps damage data, Curve II represents the Historical Data from the 1965 Corps report (1964 dollars), Curve III Historic Flood Damages ('75) are Curve II values escalated to 1975 dollars and Curve IV

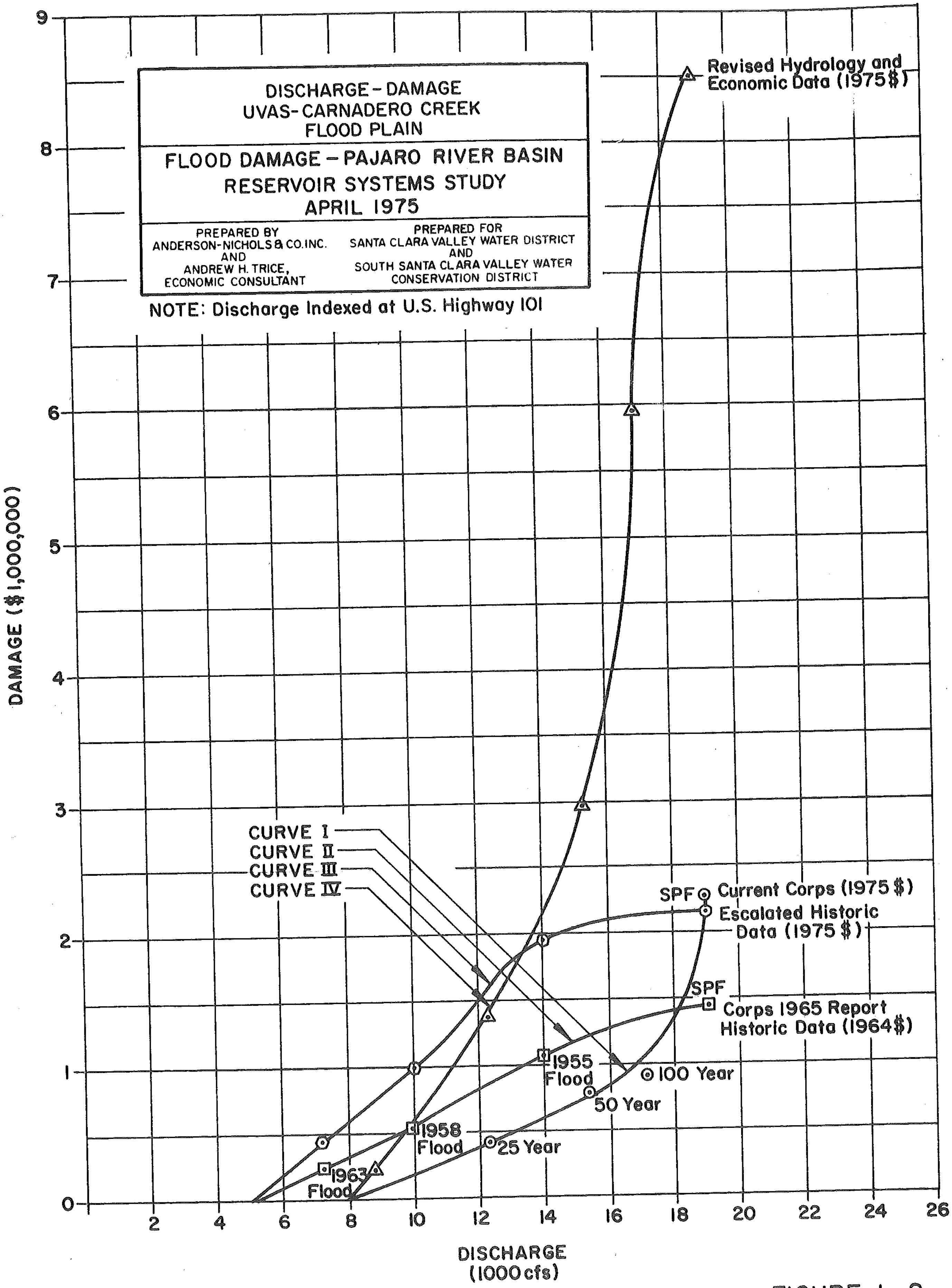

DISCHARGE - DAMAGE
UVAS-CARNADERO CREEK
FLOOD PLAIN
FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975
PREPARED BY
ANDERSON-NICHOLS & CO.INC.
AND
ANDREW H. TRICE,
ECONOMIC CONSULTANT
PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT
NOTE: Discharge Indexed at U.S. Highway 101
Revised Hydrology and Economic Data (1975$)
CURVE I
CURVE II
CURVE III
CURVE IV
SPF
Current Corps (1975 $)
Escalated Historic Data (1975 $)
SPF
Corps 1965 Report Historic Data (1964$)
1955 Flood
100 Year
50 Year
1958 Flood
25 Year
1963 Flood
DAMAGE ($1,000,000)
0
1
2
3
4
5
6
7
8
9
DISCHARGE (1000cfs)
2
4
6
8
10
12
14
16
18
20
22
24
26

FIGURE 1-2

represents the expected discharge-damage curve based upon revised hydrology and economics resulting from this study.

Computer simulation to determine average annual damage was performed for three damage data sets for existing conditions (without Hayes Valley Reservoir) and for "with project" conditions consisting of flood control storage in Uvas, Chesbro and Hayes Valley Reservoirs and a high capacity diversion from Uvas to Hayes Valley Reservoir. This resulted in the average annual damage reduction (flood control benefit) for the Hayes Valley Reservoir in the Uvas-Carnadero Creek area.

These curves produce significantly different flood control benefit values for Hayes Valley Reservoir. Table 1-1 presents the average annual damage for existing condition, "with project" and the difference of damage reduction for the three discharge-damage data curves. All values are based upon 1975 dollars with no future escalation.

TABLE 1-1
UVAS-CARNADERO

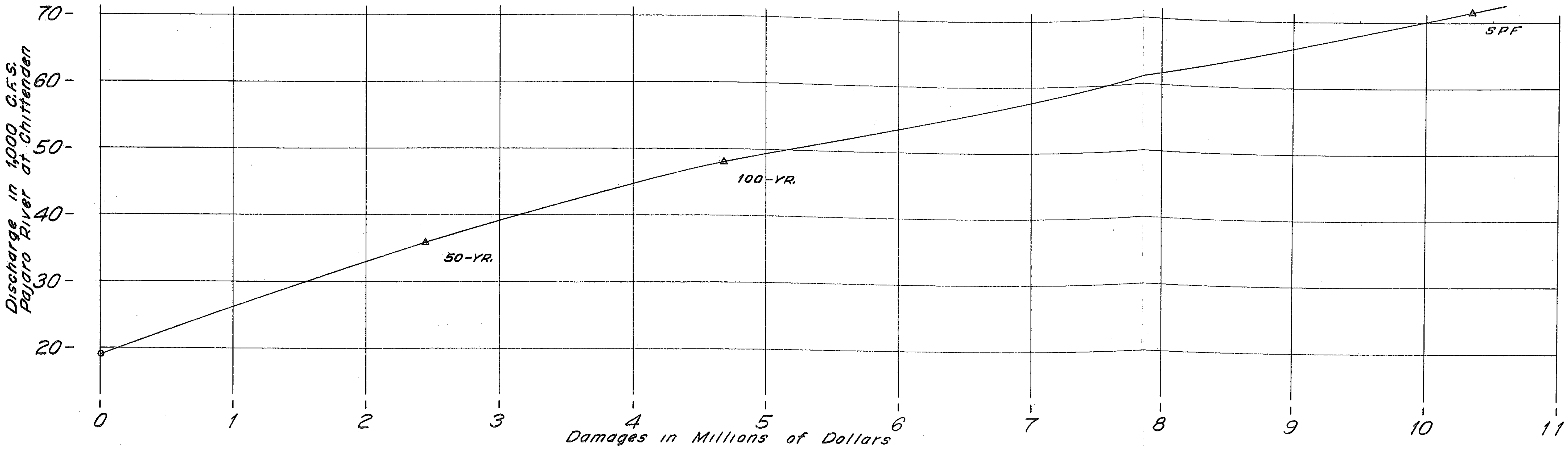
AVERAGE ANNUAL DAMAGE COMPARISON
1975 DOLLARS, NO FUTURE ESCALATION

Curve No.	Discharge Damage Data	Average Annual Damage Existing Condition	Average Annual Damage With Hayes Valley Reservoir	Damage Reduction
I	1975 Corps of Engineers	$ 55,200	$14,700	$ 40,500
III	Historic Flood Damage ('75)	178,600	68,800	109,800
IV	Revised Hydrology and Economics	194,000	37,000	157,000

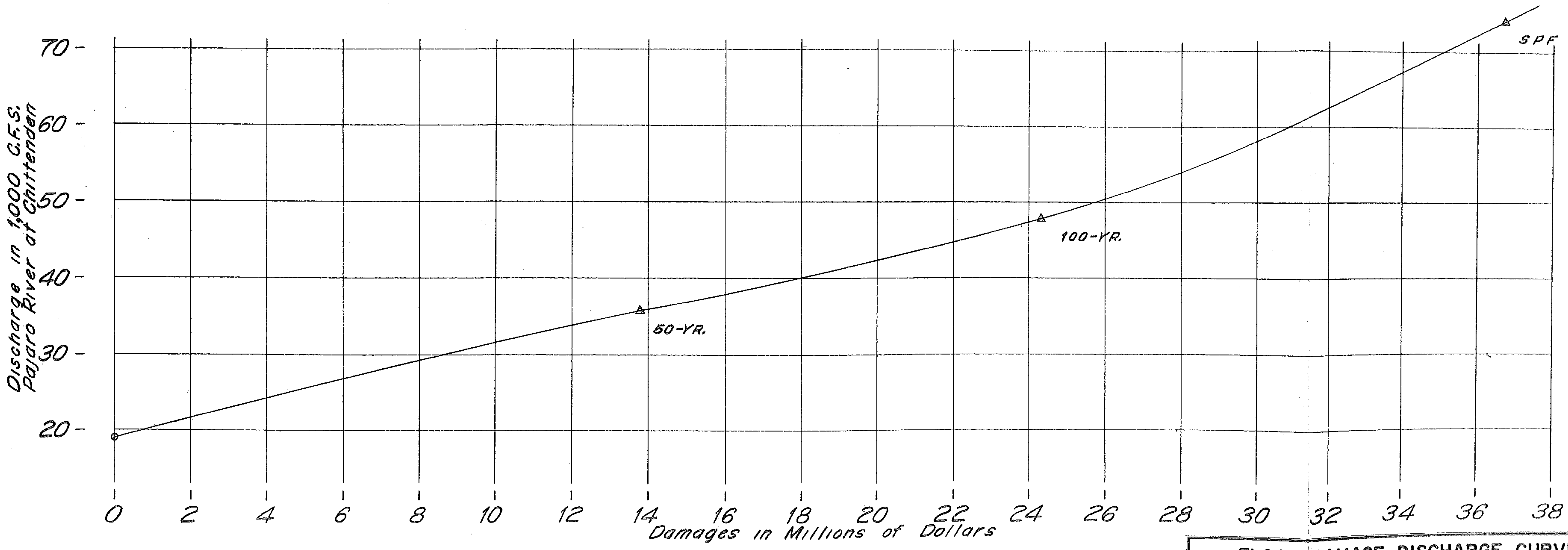
LOWER PAJARO RIVER BASIN DAMAGE EVALUATION

An investigation was performed to determine the effect of flood control reservoir regulation upon damages in the Lower Pajaro River Basin near Watsonville. The HEC-5C Model was expanded to include flows originating out of each major subbasin; Uvas-Carnadero Creek, Llagas Creek, Pacheco Creek, San Benito River and flow in the main stem Pajaro River. Flood control storage in Uvas Reservoir, Chesbro Reservoir, Hayes Valley Reservoir and Pacheco Creek North Fork Dam was investigated and surcharge storage was included for Hernandez Reservoir. Discharge-damage data for the Watsonville-Pajaro area, Figure 1-3, represents existing condition (1975 dollars) as developed by the San Francisco District Corps of Engineers for recent studies of alternative local protection projects for flood control in the Lower Pajaro River Basin. Damage reaches II and III of the Lower Pajaro River as defined in San Francisco District Corps of Engineers Information Pamphlet, "Flood Control Alternatives for Pajaro Valley, Pajaro River, Salsipuedes and Corralitos Creek," dated July 1974 are included in this study since this area would be affected by control of flood flows originating in the Upper Pajaro River Basin. These flood prone areas on the Lower Pajaro River Basin are shown in Fig. 3-1.

Average annual damage calculations were performed for four flow conditions; 1) Natural - no reservoir operation or surcharge routing, 2) Existing - Uvas, Chesbro, North Fork and Hernandez Reservoirs assumed full with spillway surcharge routing of flood



REACH III
SALSIPUEDES CREEK TO MURPHY'S CROSSING



REACH II
STATE HIGHWAY 1 TO SALSIPUEDES CREEK

FIG. I-3

FLOOD DAMAGE DISCHARGE CURVE
PAJARO RIVER
AT WATSONVILLE

FLOOD DAMAGE - PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
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SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT

flows, 3) With Project - flood control storage in Uvas and Chesbro Reservoirs plus proposed Hayes Valley Reservoir, 4) With Project plus flood control storage reservation in North Fork Dam, Pacheco Creek. The results of this analysis are summarized in Table 1-2.

TABLE 1-2

WATSONVILLE DAMAGE REACHES II AND III
AVERAGE ANNUAL DAMAGE COMPARISON
1975 DOLLARS, NO FUTURE ESCALATION

	Average Annual Damage			
Reach	Natural	Existing	With Project (Hayes Valley Reservoir)	With Project Plus North Fork Dam
II	$716,000	$638,000	$569,000	$510,000
III	147,000	129,000	115,000	104,000
Total	$863,000	$767,000	$684,000	$614,000

This results in average annual damage reduction (flood control benefit) for Hayes Valley Reservoir equal to $83,000. This is based on existing conditions at Watsonville with no future escalation or modification due to pending local flood control projects. In addition, $70,000 average annual damage can be obtained by operating North Fork Dam for flood control. This latter alternative would require the current water conservation capability at the North Fork Dam to be replaced by another source, such as imported water.

CONCLUSIONS

The Hayes Valley Reservoir project has potential to provide significant flood control benefits not only in the Uvas-Carnadero area but also in the Lower Pajaro River Basin. Due to the short time available to perform this study many refinements were not included, which are expected to increase the net flood control benefits. For example, loss of life and catastrophic damage resulting from failure and/or overtopping of levees could not be ascertained in this study.

Further, during the major flood events, the hydraulic studies indicate that an estimated 7 or 8 major highway and railroad bridges, 12 to 15 secondary road bridges and uncounted farm bridges would be destroyed or rendered unusable. This coupled with inundation of miles of highways including Highway 101, Highway 152, and other major arteries would interrupt all highway and rail traffic for several weeks. Thus, there are many primary damages ranging from loss of life and structural damage to traffic interruption which have not been addressed nor included in this report.

Future escalation was not included in this study. However, the Corps 1975 report proposed an annual flood control benefit, credited to Hayes Valley Reservoir, of $58,000, which was augmented by $57,000 of locational benefits and $88,000 for cost savings due to elimination of floodproofing, a total of about $200,000 annual flood control benefit. The additional refinements made in this study, including the additional damage reach, indicate the annual flood control benefits would be approximately $240,000 without consideration of locational and floodproofing benefits. This is a 400 percent increase over the $58,000 used for the previous Corps evaluation. Addition of specific benefits, including the $145,000 cited above, could raise the total benefit to $400,000 to $500,000. Further, these values do not include benefits for flood control operation of Chesbro Reservoir made possible by the Hayes Valley Project.

In summary, the following points are presented:

The Hayes Valley Project has flood control benefits beyond those included in the 1975 analysis by the Corps.

1. Results of computer (HEC-2) backwater studies showed that significant levee overtopping would begin to occur in the City of Gilroy and neighboring areas at a flow of 7,000 cfs. This is one of the major differences between the finding of this study and those of the Corps presented to the Citizens Advisory Committee in January, 1975.

2. The overtopping will occur at a number of locations one of which would pose an immediate danger to new homes and construction including a high school costing in excess of $9 million. But more important, it could result in the loss of lives through a levee failure such as that described in the findings of our consultant.

3. Flood damages in the reach from Hecker Pass to the base of Uvas Dam was omitted from the Corps' evaluation of damage. This is Reach VII, as designated in this report, and during the 100-year flood, approximately 950 acres and about 70 homes would be inundated. Omitted from the Corps' study of Reach 1, was the floodplain area of Soap Lake located in San Benito County. This floodplain area ranges between 200 and 8,000 acres depending on the severity of the flood. It is regularly flooded (see frontispiece) and a significant reduction in flooded area could be effected if the proposed Hayes Valley Reservoir is constructed.

4. The study of agricultural damage showed that, because of South Santa Clara Valley's conversion from orchards to row crops, up to 7,000 acres of agricultural land are vulnerable to even greater damages than that registered in the 1955 flood. Agricultural damage, alone, totaled $1.5 million in 1955 dollars.

These row crops receive early winter topsoil preparation, fertilization and herbicide treatment which, except for harvesting, represents the major cost of farming these crops. In addition, because of this preparation, there is a high probability of the loss of much of the topsoil due to erosion, transport and gullying. Thus, there is a distinct possibility that the successive year's crops would not be produced or might be marginal.

5. The proposed Hayes Valley Reservoir would, in addition to the damage reduction in the Upper Pajaro River (Gilory area), also

provide $85,000 average annual damage reduction in the Lower Pajaro River Basin at Watsonville and surrounding areas.

6. The results of these analyses culminated in the preparation of a new flood damage curve which when integrated over the life of the proposed project shows that estimated flood control benefits for the proposed offstream storage facility at Hayes Valley would be as follows:

AVERAGE ANNUAL DAMAGE REDUCTION
AND OTHER BENEFITS OF
HAYES VALLEY RESERVOIR PROJECT

Upper Pajaro Basin (Gilroy and neighboring areas)	$ 157,000	
Lower Pajaro Basin (Watsonville and surrounding areas)	83,000	
Subtotal (Damage Reduction under existing conditions)		$ 240,000
Locational Benefits (Corps' Report to Advisory Committee)	47,000	
Floodproof Benefits (Corps' Report to Advisory Committee)	88,000	
Subtotal (Future Benefits)		135,000
Elimination of Raising Chesbro Reservoir (PL566 Project - 5/75)		248,000
TOTAL FLOOD CONTROL BENEFITS		$ 623,000
WATER SUPPLY AND RECREATION BENEFITS (1975 Corps' Data)		2,367,000
	TOTAL BENEFITS	$2,990,000

7. With the Corps' estimate of $2.73 million for the average annual cost of construction of Hayes Valley Reservoir, the Hayes Valley Reservoir Project benefit cost ratio is about 1.1 to 1. This calculation does not consider benefits such as anadramous fishery enhancement, onstream recreation benefits and San Felipe terminal storage for South Valley distribution.

We feel the flood damages presented in this report are realistic yet conservative. For example, if the $1.8 million flood damages experienced in 1955 in the Upper Pajaro region are escalated by the same factor used in other Corps' studies, e.g. "Flood Control Alternatives for Pajaro River Valley. . ." July, 1974, those same damages, in 1975, would total in excess of $6 million.

In conclusion we wish to underscore concern that we believe there is a very serious potential flood damage problem in South Santa Clara County and that there is a federal interest in the solution of the problem.

We believe there are many areas and considerations which should be more completely investigated by the Corps in this next fiscal year. That the Corps should continue its study of a multi-purpose solution to this problem and the offstream reservoir at Hayes Valley is a solution which is highly recommended by the citizens of the South Valley.

SECTION 2

HYDROLOGY-HYDRAULIC ANALYSIS

This section provides a detailed description of the data, assumptions and procedures used during the development of hydrologic and hydraulic analyses to evaluate the Hayes Valley Reservoir project for flood control benefits. The majority of work was performed with three different computer simulation models. The primary model was developed from the computer program HEC-5C, Simulation of Flood Control and Conservation Systems, written by Bill S. Eichert, Director of The Hydrologic Engineering Center (HEC), Army Corps of Engineers, Davis, California. The HEC-5C Model was used to perform flood routing while operating the existing reservoirs and proposed Hayes Valley Reservoir for flood control. The second program, HEC-2, Water Surface Profiles, was used to develop multiple discharge water surface profiles for the Uvas-Carnadero Creek in order to delineate the floodplain for different frequency events and to locate areas where levee overtopping with potential levee failure is likely to occur in the Gilroy area. The third model was developed from the HEC program, Gradually Varied Unsteady Flow Profiles. This model was used to approximate overland flow after a levee failure in order to define a velocity field and depth profile.

The following descriptions provide the data, assumptions and procedures used for each model application. The Appendix, under separate cover, provides the output result from each significant computer simulation run. For a detailed description of each computer program, the Users Manual is available from the Army Corps of Engineers, The Hydrologic Engineering Center, Davis, California.

FLOOD CONTROL RESERVOIR OPERATION - HEC-5C MODEL

A Model of the Upper Pajaro River Basin using HEC-5C was developed by the Santa Clara Valley Water District and used for their report, Report on Multi-Purpose Operation of Uvas-Chesbro and Proposed Valley Reservoir, dated August 1974. This Model was expanded during this study to include the entire Pajaro River Basin.

The Model computes the effects of reservoir flood control operation at discrete locations, termed control points. To simulate a particular flood event, the Model routes flood hydrographs through the Basin while operating each reservoir according to prescribed release criteria designed to reduce flooding at specified downstream control points, or damage center. The Model tabulates for each control point and for each incremental time period both the natural and modified (regulated) flood hydrograph, as well as reservoir storage and the governing release rule. When provided damage-flood discharge data, the Model calculates various measures of economic effectiveness - expected average annual damage reduction, average annual damage reduction per acre-foot of available flood control storage, and the net benefit of the reservoir system (the difference between the cost of the reservoirs and the annual damage reduction attributed to them), from which the benefit-cost ratio can be determined.

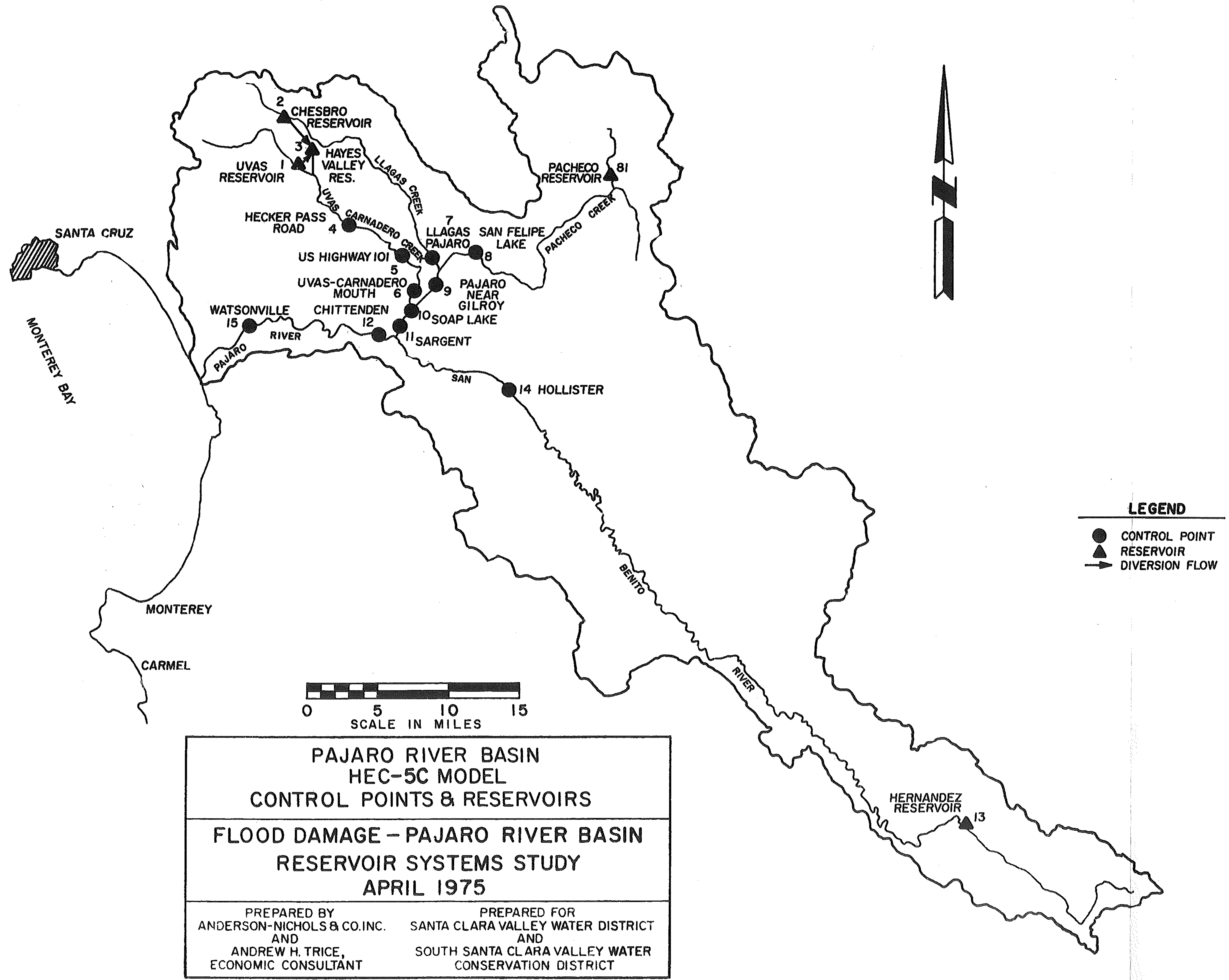
The basic analysis procedure involved the following steps. The Model is executed from a number of floods with only the existing reservoirs in operation. This provides the base condition peak discharge for each flood and the average annual damage at each damage center. The Model is then executed for the same floods with the existing reservoirs and proposed Hayes Valley Reservoir in operation. Comparison of the results from the two Model executions provides the peak discharge reduction for each flood and the average annual damage reduction at each damage center attributable to the proposed reservoir.

Basin Configuration

The Pajaro River Basin is located in the coastal area of central California about 75 miles south of San Francisco and drains an area of approximately 1,300 square miles. The main stem Pajaro River is fed by four major tributaries, Uvas-Carnadero Creek, Llagas Creek, Pacheco Creek and San Benito River. In addition, substantial local flow in the lower basin is developed from Corralitos Creek and Salsipuedes Creek. The HEC-5C Model is configured to recognize all major flow areas. Table 2-1 provides a listing of each control point used in the Model along with cumulative drainage area above the control point. Figure 2-1 shows a map of the Pajaro River Basin with the location of control points, while Figure 2-2 is a schematic diagram of the geographical locations shown in Figure 2-1.

TABLE 2-1
HEC-5C MODEL
CONTROL POINTS
LOCATION AND DRAINAGE AREA

Control Point		Drainage Area (square miles)
No.	Stream and Location	
1	Uvas-Carnadero Creek at Uvas Reservoir Damsite	30.4
2	Llagas Creek at Chesbro Reservoir Damsite	19.25
3	Hayes Valley Reservoir	-
4	Uvas-Carnadero Creek at Hecker Pass Road	65
5	Uvas-Carnadero Creek at US Highway 101	73
6	Uvas-Carnadero Creek at Confluence Pajaro River	90
7	Llagas Creek at Confluence Pajaro River	104
81	Pacheco Creek at North Fork Damsite	69
8	Pacheco Creek at San Felipe Lake	284
9	Pajaro River near Gilroy (Below Llagas and Pacheco Confluence)	399
10	Pajaro River at Soap Lake	500
11	Pajaro River at Sargent	501
12	Pajaro River at Chittenden	1186
13	San Benito River at Hernandez Reservoir Damsite	88
14	San Benito River at Hollister	586
15	Pajaro River at Watsonville	1273



PAJARO RIVER BASIN
HEC-5C MODEL
CONTROL POINTS & RESERVOIRS

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

FIG. 2–1

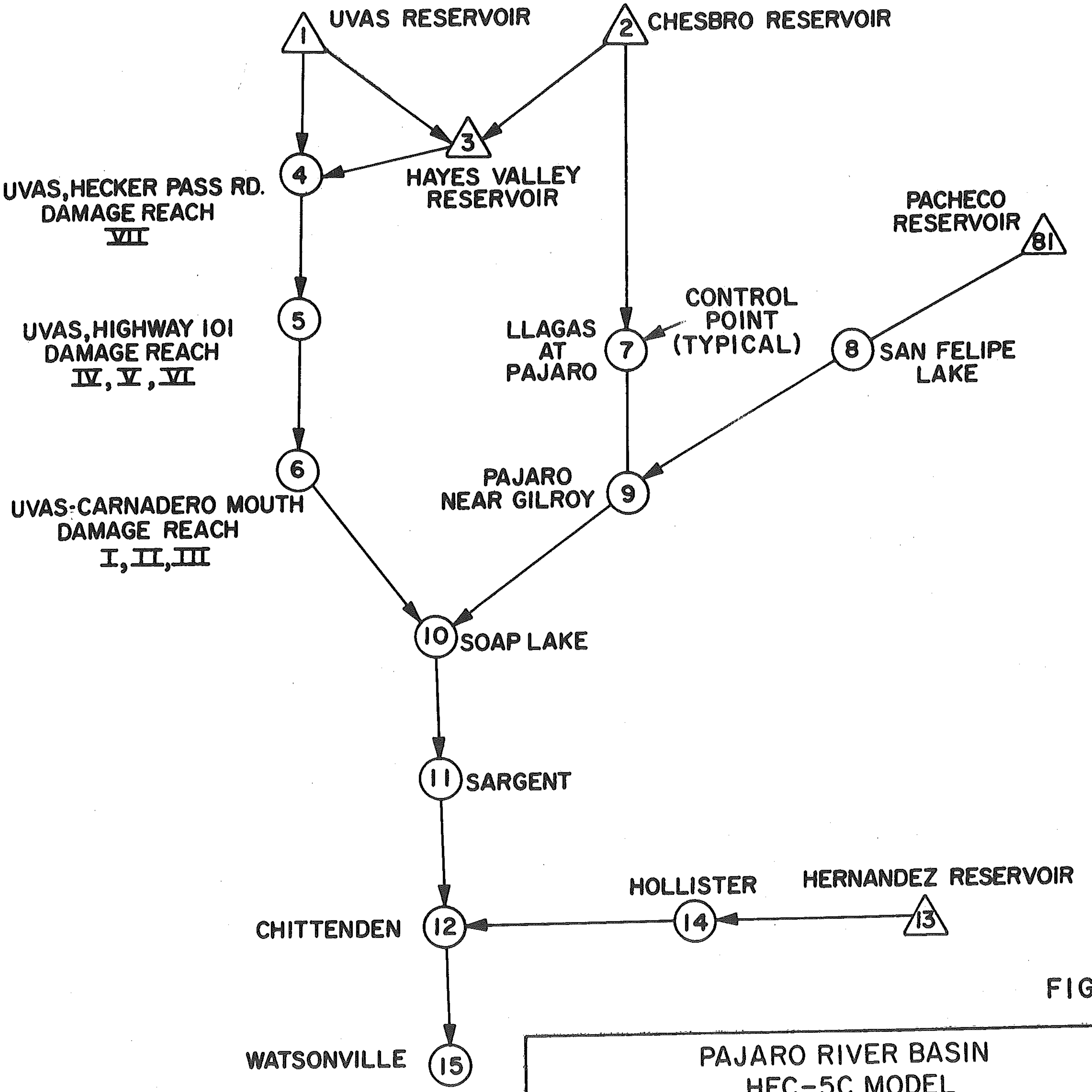


FIG. 2-2

PAJARO RIVER BASIN
HEC-5C MODEL
SCHEMATIC DIAGRAM

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

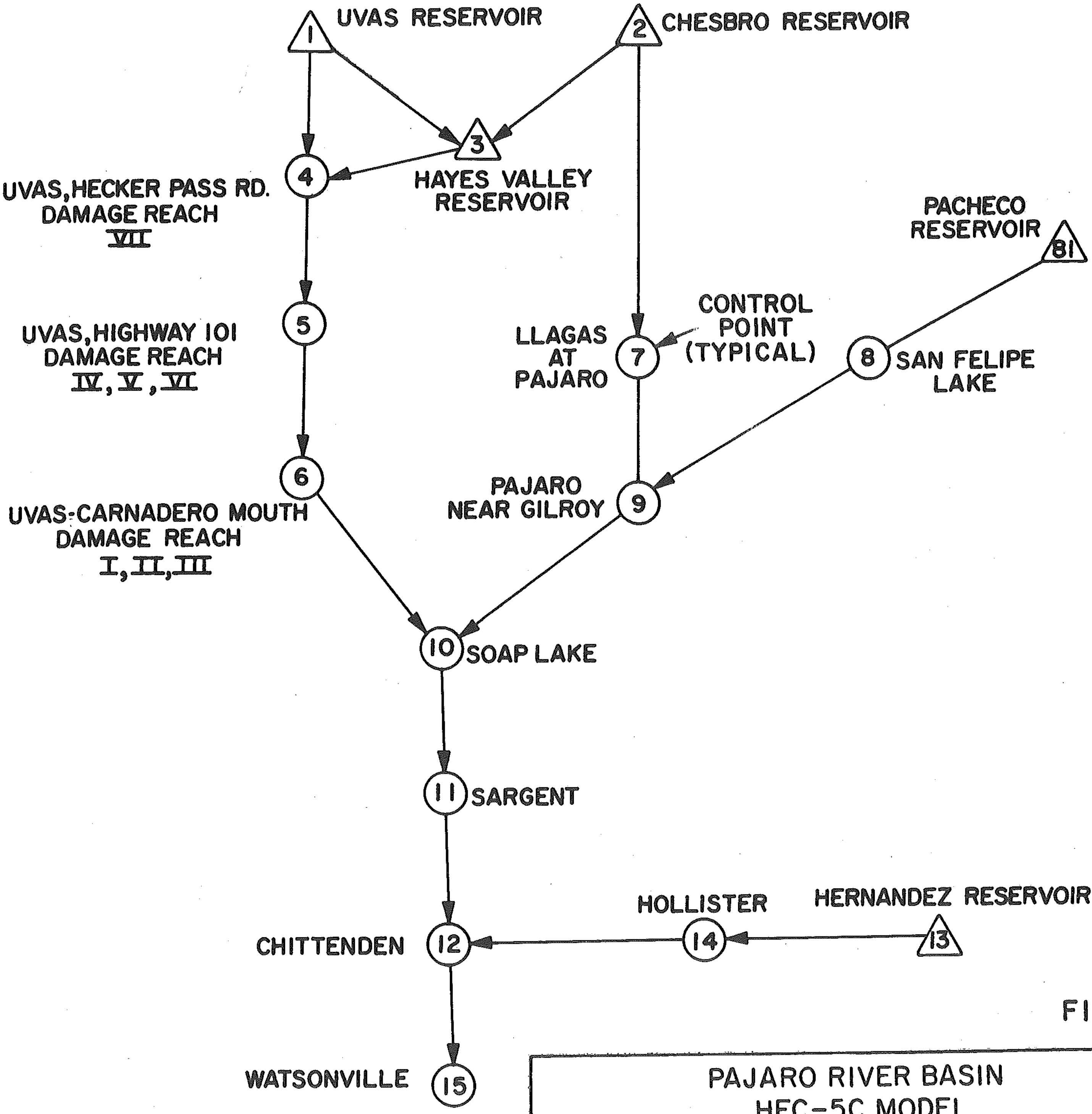


FIG. 2-2

PAJARO RIVER BASIN
HEC-5C MODEL
SCHEMATIC DIAGRAM

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	PREPARED FOR SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

The routing criteria for each reach between control points is shown in Tables 2-2 and 2-3. Muskingum routing developed by the Corps of Engineers is used for most reaches. Storage-outflow relationships were developed for San Felipe Lake and Soap Lake. Modified Puls routing was used for these two reaches in order to reflect the appropriate storage-outflow relationship for each lake.

Diversion flow is provided from Uvas Reservoir to Hayes Valley Reservoir and from Chesbro Reservoir to Hayes Valley Reservoir. This criteria is summarized in Table 2-4 and is the same as used for the Santa Clara Valley Water District study of Hayes Valley Reservoir referenced above.

Flow Data

Synthetic hydrographs were used for each HEC-5C control point to develop a set of consistent flood hydrographs to represent flow throughout the basin. The Corps of Engineers Standard Project Flood (SPF) hydrographs developed by the San Francisco District were used for flow in the Uvas-Carnadero Creek, Pacheco Creek and San Benito River. The Soil Conservation Service (SCS) hydrographs were used for flow in Llagas Creek. The Llagas Creek hydrographs were verified by the Santa Clara Valley Water District using HEC-1 to simulate the rainfall runoff process. Tabulations of the base hydrographs used in this study are presented in tables 2-5 thru 2-11.

TABLE 2-2

MUSKINGUM ROUTING CRITERIA

(Routing Interval = 1 hour)

Routing Reach					
U/S Control Point	D/S Control Point	Number of Steps	K (hours)	X	Total K (hours)
1	4	2	.87	0	1.74
* 1	3	1	0	.5	0
2	7	5	.94	0	4.7
* 2	3	1	0	.5	0
3	4	2	1.18	0	2.36
4	5	1	.87	0	.87
5	6	1	1	0	1
6	10	1	0	.5	0
7	9	1	1	0	1
81	8	3	1	.3	3
9	10	1	1	0	1
11	12	2	1	.5	2
12	15	2	1	.5	2
13	14	12	1	.4	12
14	12	4	1	.3	4

Note: K = 0, X = .5 results in straight translation with no routing effect on hydrograph

*Diversion Flow

TABLE 2-3

MODIFIED PULS ROUTING CRITERIA

(Routing Interval = 1 hour)

Routing Reach		Number of Steps	Storage-Discharge Curve	
U/S Control Point	D/S Control Point		Storage (acre-feet)	Discharge (cfs)
8	9	2	0	0
			500	300
			1,000	600
			2,500	3,000
			8,750	7,000
			35,000	9,500
			60,000	21,000
10	11	2	0	0
			3,000	300
			8,000	1,700
			17,000	13,000
			17,500	15,500
			22,000	29,500
			30,000	56,000

TABLE 2-4

DIVERSION CRITERIA*

Diversion Reach		Diversion Pipe Capacity as Function of Reservoir Storage	
From Control Point	To Control Point	Discharge (cfs)	U/S Storage (acre-feet)
1	3	0	0
		2,100	3,000
		2,600	4,000
		3,000	5,000
		3,400	6,100
		3,700	7,000
		3,900	8,000
		4,200	10,000
		4,200	10,900
		4,000	15,000
2	3	0	0
		300	105
		795	3,664
		805	4,391
		850	6,555
		850	8,086
		900	8,647
		930	9,488
		950	10,412
		1,000	11,034

*Diversions are equal to the excess flood waters above the top of conservation pool up to the outlet capacity of the diversion pipe. Routing criteria for diversion flow shown in Muskingum Routing Criteria Table.

TABLE 2-5

DISCHARGE HYDROGRAPH

UVAS CREEK AT UVAS RESERVOIR

Corps of Engineers Standard Project Flood

Hour	Day 1	Day 2	Day 3
1	800	9800	3400
2	800	9900	3000
3	800	9600	2600
4	1300	9100	2000
5	1800	8700	1700
6	2100	8400	1400
7	2400	8000	1200
8	2700	7800	1000
9	3000	7500	900
10	3100	7300	800
11	3000	7000	700
12	2800	6800	600
13	2600	6600	500
14	2500	6500	400
15	2300	6600	400
16	2000	6500	400
17	1900	6200	400
18	1800	5800	400
19	1700	5200	400
20	2300	4700	400
21	3200	4200	400
22	4900	3900	400
23	6400	3800	400
24	9000	3600	400

TABLE 2-6

DISCHARGE HYDROGRAPH

UVAS-CARNADERO CREEK AT US HIGHWAY 101

Corps of Engineers Standard Project Flood

Hour	Day 1	Day 2	Day 3
1	2000	16600	6600
2	2000	18400	6000
3	2000	18900	5400
4	3000	18600	5000
5	3700	18000	4600
6	4300	17200	4200
7	4800	16700	3700
8	5100	16200	3400
9	5400	15600	3100
10	5600	15100	2800
11	5700	14800	2500
12	5600	14500	2300
13	5400	14200	2100
14	5000	14000	1900
15	4600	13700	1700
16	4300	13600	1600
17	4000	13000	1400
18	3700	12400	1300
19	3700	11800	1200
20	4000	10900	1200
21	4800	9800	1100
22	6000	9000	1100
23	10000	8300	1000
24	13600	7400	1000

TABLE 2-7

DISCHARGE HYDROGRAPH

LLAGAS CREEK AT CHESBRO RESERVOIR

Soil Conservation Service Hydrograph as Reconstituted by Santa Clara Valley Water District

Hour	Day 1	Day 2	Day 3
1	13	3800	0
2	13	4500	0
3	13	7600	0
4	13	4800	0
5	13	4300	0
6	13	3700	0
7	13	3200	0
8	13	2700	0
9	50	2200	0
10	230	1700	0
11	470	1100	0
12	790	760	0
13	1200	480	0
14	1600	300	0
15	1900	190	0
16	2000	110	0
17	2100	70	0
18	2200	40	0
19	2200	20	0
20	2300	10	0
21	2400	0	0
22	2600	0	0
23	2900	0	0
24	3300	0	0

TABLE 2-8

DISCHARGE HYDROGRAPH

LLAGAS CREEK ABOVE CONFLUENCE WITH PAJARO RIVER

Soil Conservation Service Hydrograph as Reconstituted
by Santa Clara Valley Water District

Hour	Day 1	Day 2	Day 3
1	640	12200	730
2	640	15100	640
3	640	18200	580
4	640	18700	540
5	640	18100	510
6	640	16600	500
7	640	14900	490
8	640	13300	490
9	720	11800	490
10	980	10200	480
11	1500	8500	480
12	2200	7000	480
13	3300	5600	480
14	4400	4500	480
15	5400	3700	480
16	6100	3100	480
17	6700	2600	480
18	7000	2100	480
19	7200	1800	480
20	7400	1500	480
21	7800	1300	480
22	8400	1100	480
23	9300	970	480
24	10500	840	480

TABLE 2-9

DISCHARGE HYDROGRAPH

PACHECO CREEK AT SAN FELIPE LAKE

Corps of Engineers Standard Project Flood

Hour	Day 1	Day 2	Day 3
1	500	23000	10500
2	500	32000	9000
3	500	37000	8000
4	1500	42000	7000
5	3500	44500	6000
6	5500	45000	5500
7	9000	44000	5000
8	11500	42500	4500
9	14000	40000	4500
10	15500	37500	4000
11	16000	35000	3500
12	15500	32000	3000
13	14000	29000	3000
14	13000	26000	2500
15	11500	23000	2000
16	9500	21500	2000
17	8000	20000	2000
18	6500	19000	2000
19	5500	18000	1500
20	5000	17500	1500
21	5500	16500	1500
22	7500	15000	1500
23	10000	13500	1500
24	15000	12000	1500

TABLE 2-10

DISCHARGE HYDROGRAPH

SAN BENITO RIVER AT HERNANDEZ RESERVOIR

Corps of Engineers Standard Project Flood

Hour	Day 1	Day 2	Day 3
1	500	2500	6000
2	500	2000	5000
3	500	1500	4500
4	500	1500	4000
5	500	1000	5000
6	500	1000	5500
7	500	1000	4500
8	500	1000	4000
9	500	1000	3000
10	500	2000	2500
11	500	4000	2000
12	500	7500	2000
13	500	10000	1500
14	500	13500	1500
15	500	15500	1000
16	500	14500	1000
17	1500	12500	1000
18	3500	11500	1000
19	4500	11500	1000
20	4000	11500	1000
21	4000	10500	500
22	4000	9000	500
23	3500	8000	500
24	3000	7000	500

TABLE 2-11

DISCHARGE HYDROGRAPH

SAN BENITO RIVER NEAR HOLLISTER

Corps of Engineers Standard Project Flood

Hour	Day 1	Day 2	Day 3
1	500	9500	48000
2	500	9500	47000
3	500	9500	45000
4	500	10000	43500
5	500	10500	41000
6	500	11500	39000
7	500	12000	37500
8	1000	11500	35500
9	1000	10500	34000
10	1000	10000	31000
11	1000	10000	27500
12	1000	11500	25000
13	1000	14500	22500
14	1000	21000	20500
15	1000	26500	19500
16	1000	31500	18500
17	2000	34500	17000
18	3000	35500	15500
19	4000	36000	14000
20	5500	36000	12500
21	7000	38000	11500
22	8500	42000	10000
23	9000	45000	9000
24	9000	47000	8000

The timing of these hydrographs was analyzed by evaluating historic events. Table 2-12 provides the peak discharge and timing of historical flood events occurring in 1963 and 1969. Table 2-13 derived from the foregoing, provides a summary of the relative timing of peak discharge used in this study between key locations in the Uvas-Carnadero Creek, Llagas Creek, Pacheco Creek and San Benito River. The Corps of Engineers SPF timing corresponded to the average historic event timing; therefore, the relative SPF timing between the Uvas-Carnadero Creek, Pacheco Creek and San Benito River hydrographs was not altered. The timing of the SCS hydrographs for Llagas Creek was based on the results of the above-mentioned historical flood evaluation and was lagged by one hour.

Cumulative discharge hydrographs for control points 4 and 6 on Uvas Creek were created from the base hydrograph at control point 5 (U.S. 101) using drainage area ratios and lead and lagging respectively according to routing criteria previously noted. A cumulative discharge hydrograph was created for upstream control point 81 (Pacheco Reservoir) from the base hydrograph at downstream control point 8 (San Felipe Lake) in the same manner. Local flows were then calculated for all control points by routing flood flows from the upstream control points and subtracting these routed values from the cumulative hydrographs at the downstream

TABLE 2-12
HISTORIC FLOOD EVALUATION
TIME AND MAGNITUDE OF PEAK DISCHAGE
(cfs)

Location	1969					1963
	January 19	January 21	January 25	January 26	February 24	February 1
Uvas Creek above Uvas Reservoir						
Discharge	3,100		2,200	2,900	2,140	
Time	0600		0100	0300	0400	
Uvas Creek near Gilroy						
Discharge						6,180
Time						0200
Llagas Creek near Morgan Hill						
Discharge	27			1,300	6,400	
Time	0700			0400	0600	
Pacheco Creek near Dunneville						
Discharge	6,000	5,000	11,300	6,400	7,210	8,900
Time	0800	1100	0600	0700	1500	0500
San Benito River near Hollister						
Discharge		1,880	4,100	3,500	8,900	
Time		0100 (1/22)	2300	1100	2100	
Pajaro River near Gilroy						
Discharge	3,970		12,900	12,800	7,500	5,330
Time	1300		2200	1100	1100 (2/25)	0500
Pajaro River at Chittenden						
Discharge	7,590	4,900	17,000	17,700	17,800	11,600
Time	1700	2000	0200 (1/26)	1400	0800 (2/25)	0900

TABLE 2-13

HISTORIC FLOOD EVALUATION

PEAK DISCHARGE LAG IN HOURS FROM PEAK DISCHARGE AT UVAS RESERVOIR

Location	1969					1963	Average
	Jan. 19	Jan. 21	Jan 25	Jan 26	Feb. 24	Feb. 1	
Llagas Creek near Morgan Hill	1			1	2		1
Pacheco Creek near Dunneville	2		5	4	11	6	6
San Benito River near Hollister			22	8	17		16

control point. Local flows, thus derived were used for all subsequent HEC-5C simulation runs (see Appendix-A). Local flow was neglected for control points 10 and 11 which have very small local drainage area. The local flow for the San Benito River below Hollister was developed by drainage area ratio and appropriate lag from local flow at Hollister. The local flow at Watsonville originating from Corralitos and Salsipuedes Creeks was taken as a constant 2500 cfs which corresponds to the discharge contribution from this area during the peak discharge at Watsonville for the SPF.

Flood routings were made using various ratios of these local flow hydrographs in order to develop discharge frequency curves modified to show the effect of reservoir regulation which were used for average annual damage calculations.

Damage Center Data

The HEC-5C Model will perform an evaluation of expected average annual damage (AAD), computed from a number of floods. Input economic data for each damage center consists of three related data arrays: Array 1 contains exceedence frequency values ranging from approximately the 1-year event to the 1000-year event; Array 2 contains the natural condition discharge corresponding to each exceedence frequency value; and Array 3 contains the damage associated with each discharge value.

The basic assumptions in the AAD analysis are that (1) damage is a single-valued function of the maximum discharge be it natural (unregulated) or regulated, and (2) there is a known relationship between maximum discharge and its exceedence frequency. The computer program converts the exceedence frequency, corresponding discharge, and associated damage data to develop a damage-exceedence frequency array. The integration of this array or curve represents the expected average annual damage.

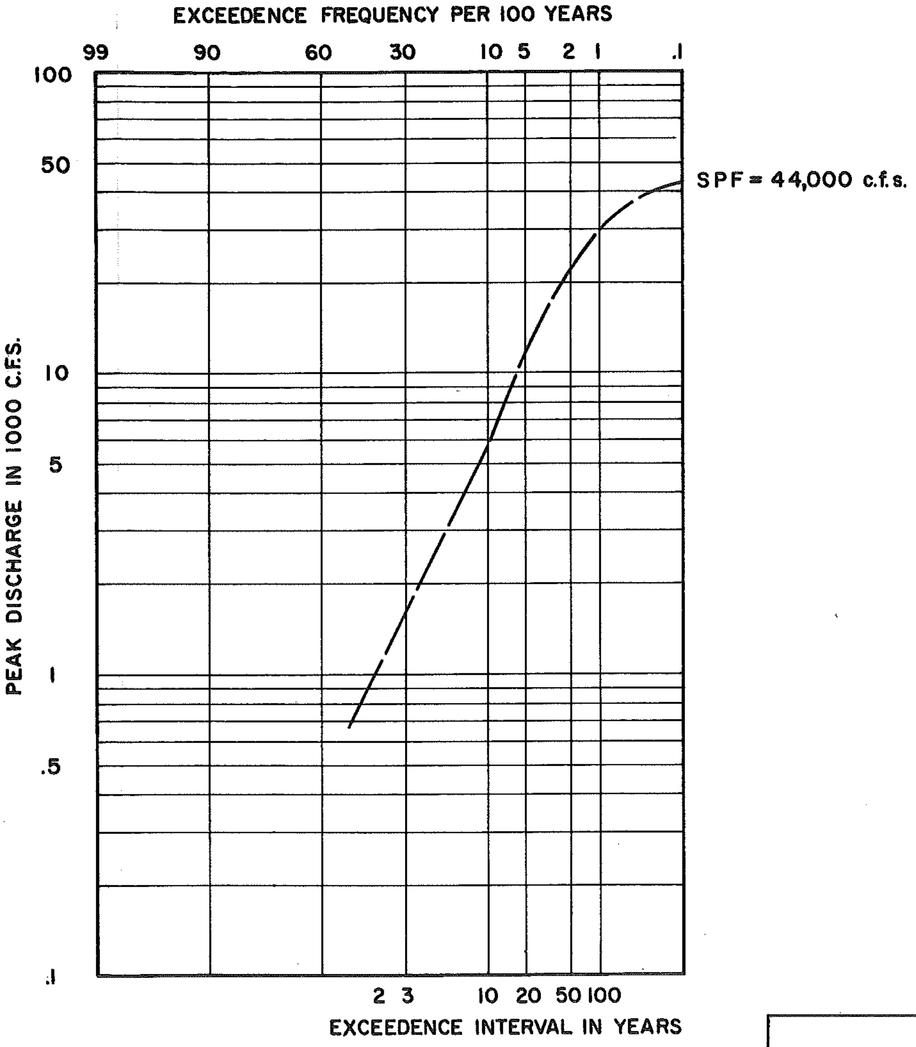
Average annual damage calculations were performed using control points (CP): CP 4-Hecker Pass Road, CP 5-U.S. Highway 101, CP 6-Uvas-Carnadero Mouth and CP 12-Chittenden to index damage for the Watsonville area. The economic data for these control points is discussed in Section 3. The discharge-frequency relationships are provided in Figure 2-3. These relationships were obtained from the San Francisco District Corps of Engineers.

Application Results

Results of the channel routing of SPF flows and computation of local inflow hydrographs are presented in the Appendix A-1. Appendix A-2 provides detailed output for the SPF, 100-year and 25-year flood events on Uvas Carnadero-Creek. The frequencies noted are for the upstream local flows and their combination results in larger floods at the downstream locations. Thus, it was necessary to "ratio" the hydrograph values to insure correspondence to adopted Corps values. A-3 through A-5 present the results of reservoir regulation on flood flows and resultant damages in the Watsonville area. Appendix A-6 through A-8 provide summary computer output for Uvas-Carnadero utilizing the three different damage curves, I, III and IV respectively.

The HEC-5C Model was reduced in size during the analysis of the Uvas-Carnadero damage evaluation in A-6 thru A-11, in order to conserve computer time. Control points 1 through 7 provide useful results with control points 9 and 10 included for convenience. A summary of peak discharge at each Uvas-Carnadero control point under this condition is shown in Table 2-14 in the column labeled "Existing Flow". Under this condition, Uvas and Chesbro Reservoirs are assumed to be full, to the spillway crest at the start of the flood hydrograph and spillway surcharge routing is used to discharge these flood flows from the reservoir. In Table 2-14, the results of using flood control storage and diversion in Uvas, Chesbro, and proposed Hayes Valley Reservoirs are presented in the column entitled "Modified Flow". The maximum storage in acre-feet for each reservoir is shown in Table 2-15. Note that under SPF conditions the maximum storage required at Hayes Valley Reservoir for control of outflow is 38,000 AF.

The complete HEC-5C Model was used to evaluate damage in the Lower Pajaro River Basin. During these simulating runs the flows derived from the Upper Pajaro River Basin (Uvas-Carnadero Creek, Pacheco Creek and San Benito River) were all multiplied by the



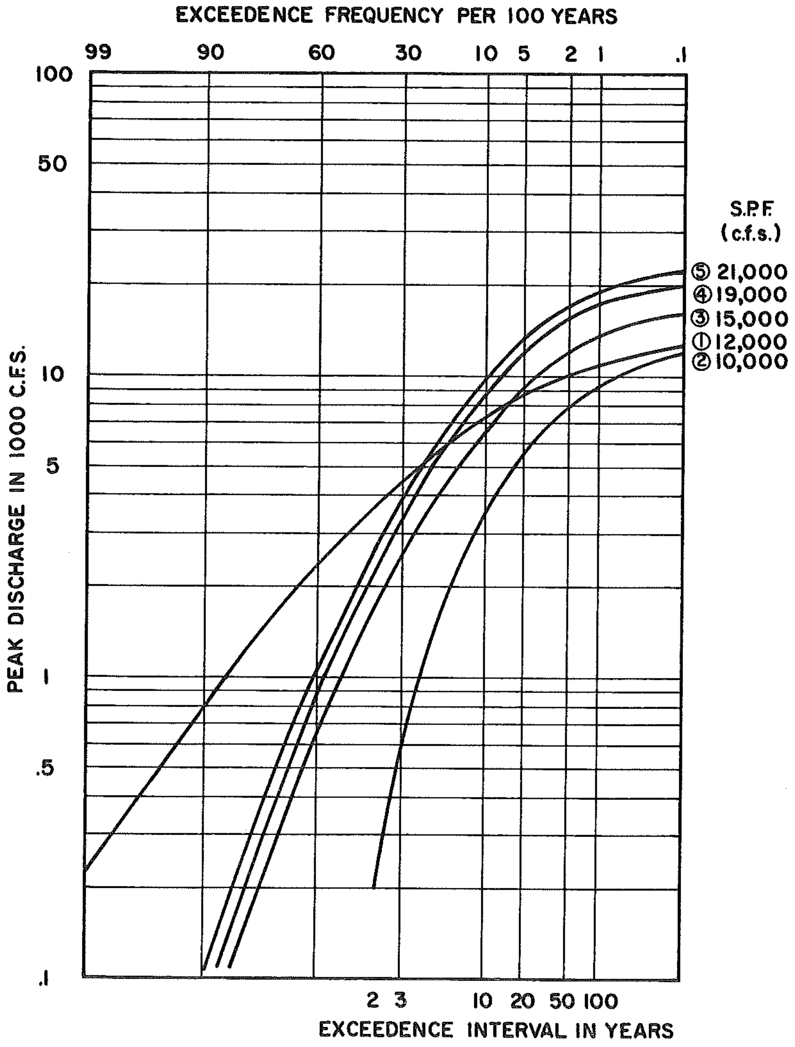
SAN BENITO RIVER AT HOLLISTER

FIG. 2-3

PEAK DISCHARGE-FREQUENCY CURVES

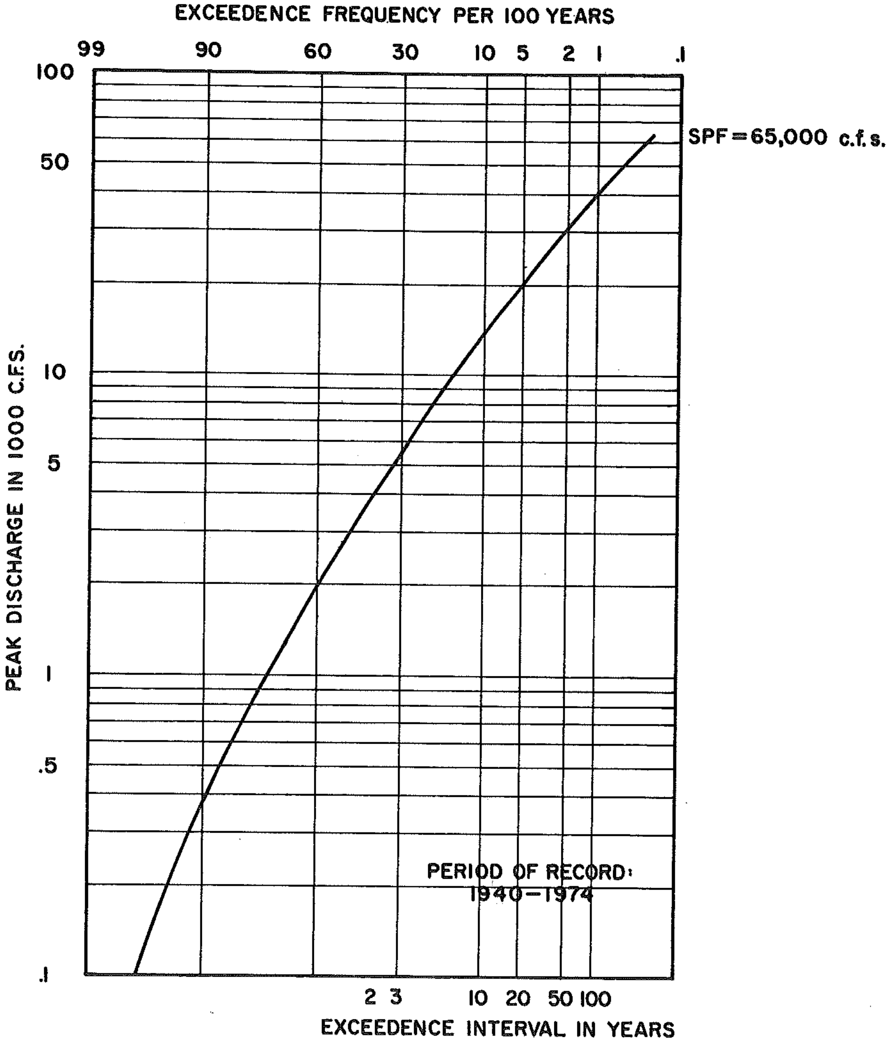
FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO.INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT



UVAS-CARNADERO CREEK

LEGEND		DRAINAGE AREA (SQ. MI.)
1	PRE-UVAS DAM INFLOW	30.4
2	SPILL FROM UVAS DAM	30.4
3	UVAS CREEK BELOW LITTLE ARTHUR CREEK	46.3
4	UVAS-CARNADERO CREEK AT U.S. HIWAY 101	73.0
5	CARNADERO CREEK AT MOUTH	90.0



PAJARO RIVER AT CHITTENDEN

TABLE 2-14

PEAK DISCHARGE
(CFS)

UVAS-CARNADERO CREEK

Location		Standard Project Flood		* 100 Year Flood		* 25 Year Flood	
Control Point	Name	Existing Flow	Modified Flow	Existing Flow	Modified Flow	Existing Flow	Modified Flow
4	Hecker Pass Road	17,000	11,100	15,300	10,000	11,100	7,200
5	US Highway 101	18,900	12,600	17,000	11,300	12,300	8,200
6	Uvas-Carnadero Mouth	20,600	14,200	18,600	12,800	13,400	9,200

See Appendix A-2

*Flood event frequencies are approximate and only indicate general frequency level of discharges shown.

TABLE 2-15

RESERVOIR STORAGE
(acre-feet)

UVAS-CARNADERO CREEK

Reservoir	Total Flood Control Storage Available	Storage Total at Top of Flood Control Pool[1]	Maximum Reservoir Storage Level		
			Project Flood	100 Year Flood	25 Year Flood
Uvas Reservoir	4,000	10,000	10,000	10,000	8,020
Chesbro Reservoir	3,650	8,650	8,500	8,070	6,260
Hayes Valley Reservoir	15,000	35,000	37,660	36,740	32,360

Total includes dead water conservation and flood control storage, but does not include spillway surcharge.

same ratio (0.77 to .09) in order to derive the desired frequency event at Chittenden. The results of these runs are shown in Appendix A-3 through A-5. Table 2-16 presents the peak discharge at Chittenden and Watsonville for four cases: Natural Flow - no reservoir effect upon flow (outflow equals inflow); Existing Flow - Uvas, Chesbro, North Fork Dam on Pacheco Creek and Hernandez Reservoirs full to spillway crest at beginning of flood with surcharge routing; Hayes Valley Regulation - flood control storage in Uvas, Chesbro and Hayes Valley Reservoir with surcharge routing in North Fork Dam and Hernandez; and Hayes Valley plus Pacheco Regulation - flood control storage in Uvas, Chesbro, Hayes Valley and North Fork Dam Reservoirs with surcharge routing for Hernandez Reservoir. The maximum reservoir storage during flood control operation of Hayes Valley plus Pacheco is set forth in Table 2-17.

WATER SURFACE PROFILES - HEC-2 MODEL

Steady flow water surface profiles were computed for Uvas-Carnadero Creek in order to delineate the floodplain for various frequency events. They were also used to locate areas near Gilroy, where levee overtopping would occur with attendant potential levee failure. In order to determine acres of flooding for various frequency events, the HEC-2 Model was used to develop water surface profiles for a range of seven different frequency events. Table 2-18 lists the events which were computed along with magnitude of flows at locations on Uvas-Carnadero Creek.

TABLE 2-16

PEAK DISCHARGE

(CFS)

LOWER PAJARO RIVER BASIN

Event*	Location	Natural Flow[1]	Existing Flow[2]	Hayes Valley Regulation[3]	Hayes Valley + Pacheco Regulation[4]
SPF					
	Chittenden	65,000	60,800	58,200	56,700
	Watsonville	67,600	63,300	60,600	59,100
100 Year					
	Chittenden	42,600	40,100	38,900	37,700
	Watsonville	44,100	41,600	40,300	39,200
50 Year					
	Chittenden	33,600	32,000	30,000	28,200
	Watsonville	34,700	33,100	31,100	29,300
25 Year					
	Chittenden	24,100	23,000	21,800	20,700
	Watsonville	24,900	23,800	22,600	21,500

*Flood event frequencies are approximate and only indicate general frequency level of discharges shown.

[1] Appendix A-3

[2] Appendix A-3

[3] Appendix A-4

[4] Appendix A-5

TABLE 2-17

RESERVOIR STORAGE

(Acre-Feet)

LOWER PAJARO RIVER BASIN

Reservoir	Total Flood Control Storage Available	Storage Total At Top of Flood Control Pool	Maximum Reservoir Storage Level			
			SPF	100-Year Flood	50-Year Flood	25-Year Flood
Uvas Reservoir	4,000	10,000	9,360	6,360	6,000	6,000
Chesbro Reservoir	3,650	8,650	6,970	5,540	5,200	5,050
Hayes Valley Reservoir	15,000	35,000	34,560	28,240	25,590	22,740
North Fork Dam	5,000	6,000	9,000	7,070	6,110	3,850
Hernandez Reservoir	0	18,000	22,680	21,290	20,650	20,060

TABLE 2-18

UVAS-CARNADERO

HEC-2 WATER SURFACE PROFILES

DISCHARGE (CFS)

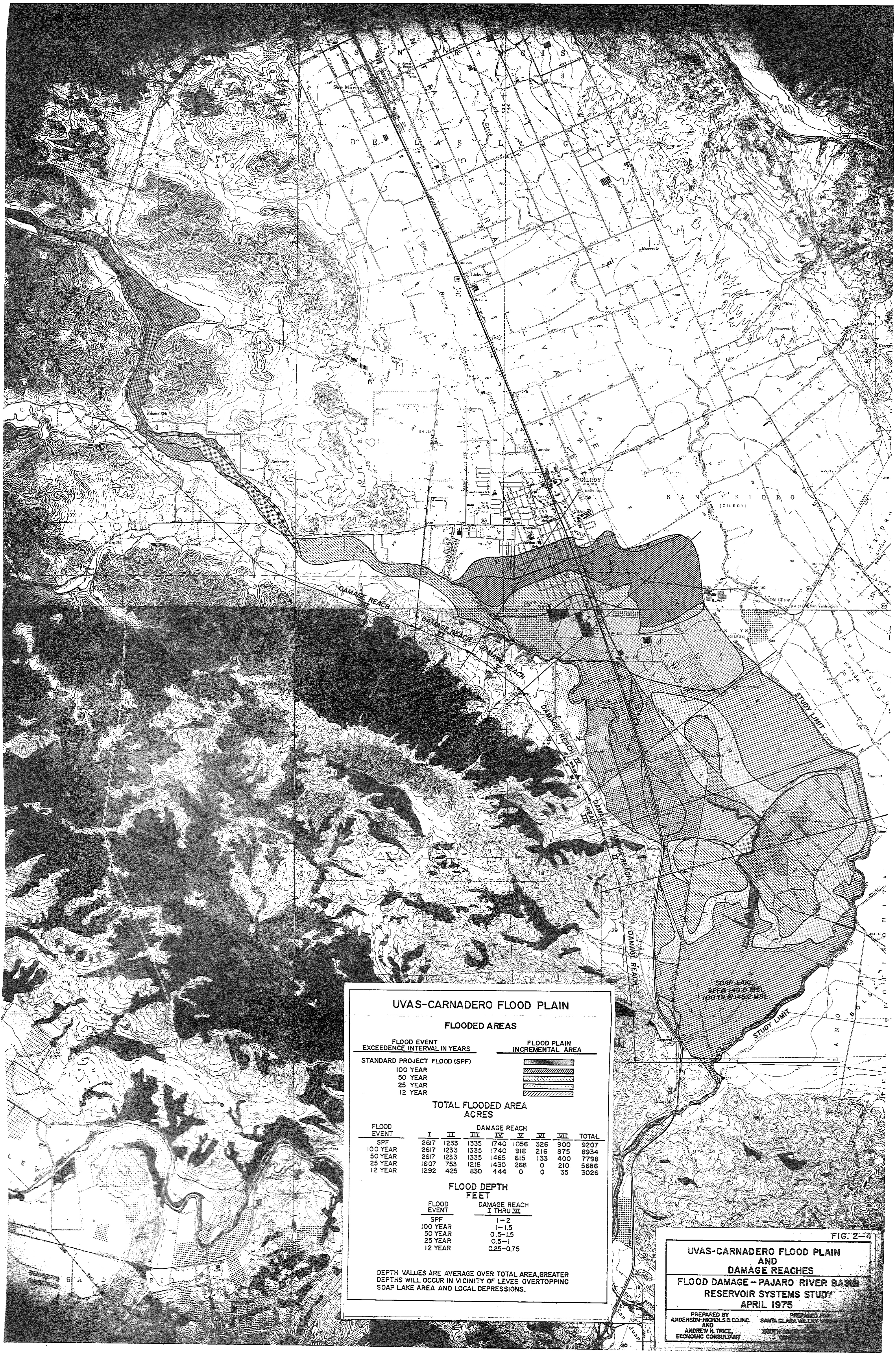
Flood Frequency	Uvas-Carnadero Mouth to US Highway 101	US Highway 101 to Santa Teresa Expressway	Santa Teresa Expwy to Little Arthur Creek	Little Arthur Creek to Uvas Reservoir
SPF	21,000	18,900	16,800	9,400
100 Year	19,000	17,100	15,300	8,500
50 Year	17,000	15,300	13,600	7,600
25 Year	15,500	13,900	12,400	6,900
17 Year	12,000	10,800	9,600	5,400
9 Year	9,000	8,100	7,200	4,000
5 Year	6,000	5,400	4,800	2,700

The HEC-2 Model was supplied by the San Francisco District Corps of Engineers and is the basic model used during their computations for the District report, Floodplain Information, Uvas-Carnadero Creek, dated May 1973.

The principal difference between this data and that utilized by the Corps in their analyses was that there was no flow reduction at Thomas Road and the flow reductions at Santa Teresa Boulevard were changed to reflect drainage areas between U. S. Highway 101 and Santa Teresa Boulevard. For the 100-year flood, the Corps used 17,100 cfs at U. S. Highway 101; 14,600 cfs at Thomas Road and 13,600 cfs at Santa Teresa Boulevard. This study used 17,100; 17,100 and 15,200 respectively at these locations. Flow data utilized in the water surface profile is shown in Table 2-18.

There also was a slight difference in the starting water surface elevations at the mouth of Uvas-Carnadero which had little effect. However, the difference in peak flood flow at Thomas Road and Santa Teresa had a significant effect and resulted in the floodplain delineation shown in Figure 2-4.

The damage curves based upon revised hydrology and economics were developed using the flooded acreage values shown on Figure 2-4. Spot elevations were taken in the Gilroy area, Figure 2-5, which allowed a more accurate delineation of the floodplain in the Gilroy area. The floodplain delineation in areas south of Gilroy (also see Figure 2-6), has the same geographic limit as the previous



UVAS-CARNADERO FLOOD PLAIN

FLOODED AREAS

FLOOD EVENT EXCEEDENCE INTERVAL IN YEARS	FLOOD PLAIN INCREMENTAL AREA
STANDARD PROJECT FLOOD (SPF)	▦
100 YEAR	▧
50 YEAR	▨
25 YEAR	░
12 YEAR	▨

TOTAL FLOODED AREA ACRES

FLOOD EVENT	DAMAGE REACH I	II	III	IV	V	VI	VII	TOTAL
SPF	2617	1233	1335	1740	1056	326	900	9207
100 YEAR	2617	1233	1335	1740	918	216	875	8934
50 YEAR	2617	1233	1335	1465	615	133	400	7798
25 YEAR	1807	753	1218	1430	268	0	210	5686
12 YEAR	1292	425	830	444	0	0	35	3026

FLOOD DEPTH FEET

FLOOD EVENT	DAMAGE REACH I THRU VI
SPF	1–2
100 YEAR	1–1.5
50 YEAR	0.5–1.5
25 YEAR	0.5–1
12 YEAR	0.25–0.75

DEPTH VALUES ARE AVERAGE OVER TOTAL AREA, GREATER DEPTHS WILL OCCUR IN VICINITY OF LEVEE OVERTOPPING SOAP LAKE AREA AND LOCAL DEPRESSIONS.

FIG. 2–4

UVAS-CARNADERO FLOOD PLAIN AND DAMAGE REACHES

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO. INC.
AND
ANDREW H. TRICE,
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY [illegible]
[illegible]
SOUTH SANTA [illegible]
[illegible]

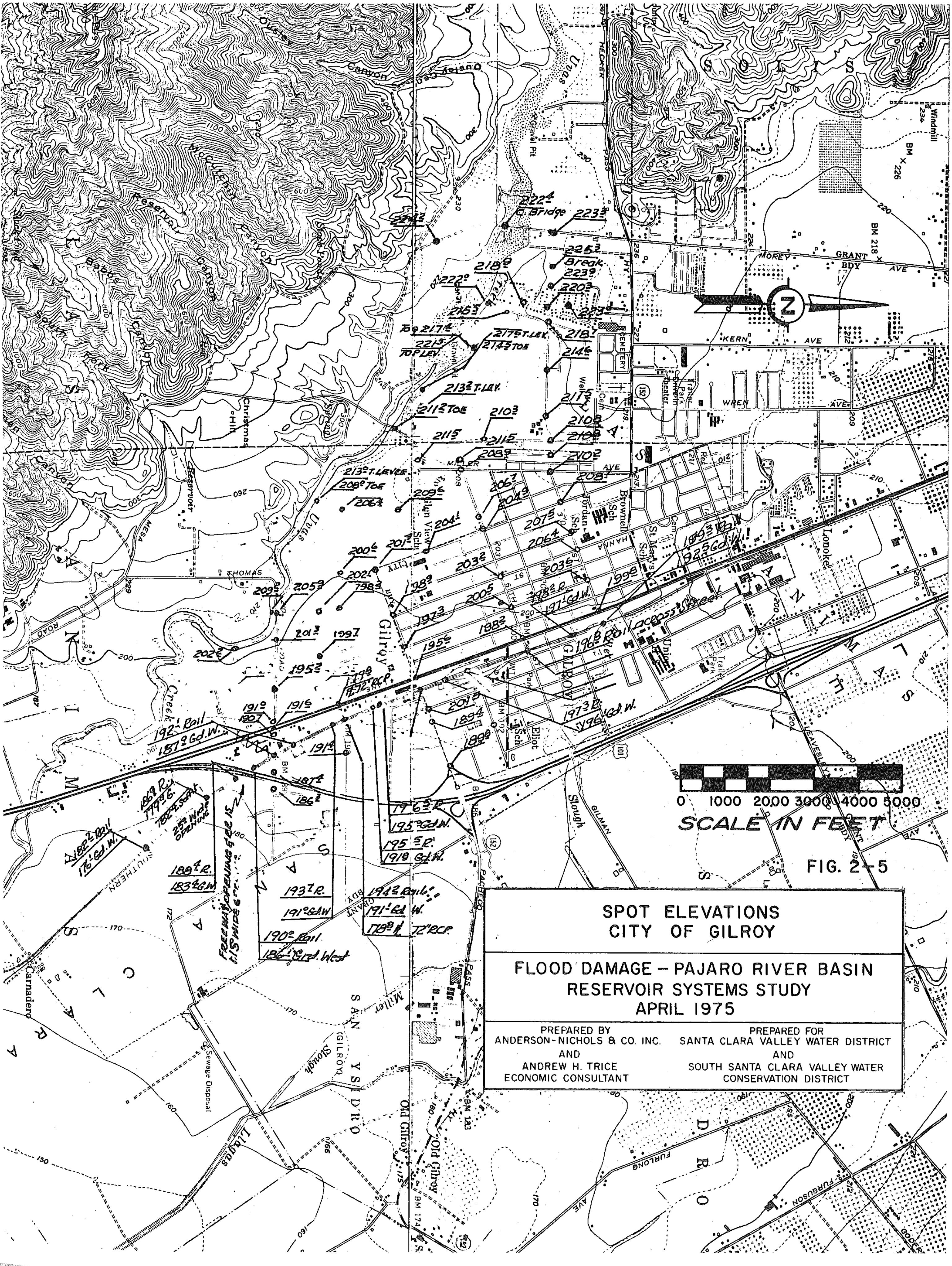


FIG. 2-5

SPOT ELEVATIONS
CITY OF GILROY

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

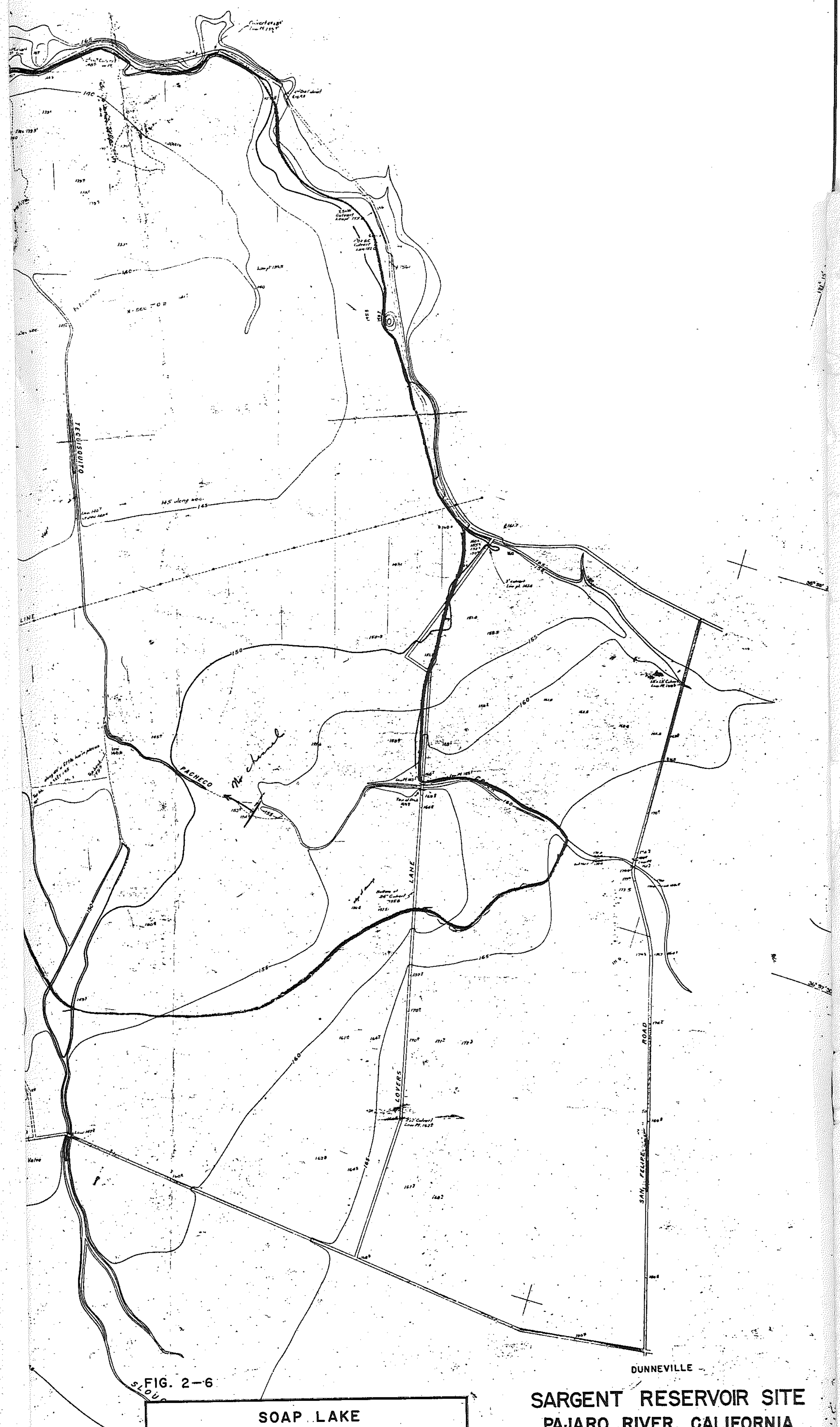


FIG. 2-6

SOAP LAKE

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO.INC.
AND

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND

SARGENT RESERVOIR SITE
PAJARO RIVER, CALIFORNIA

1 inch = 15.95 acres

SCALE IN FEET

U.S. Engineer Office, San Francisco, California

May 19

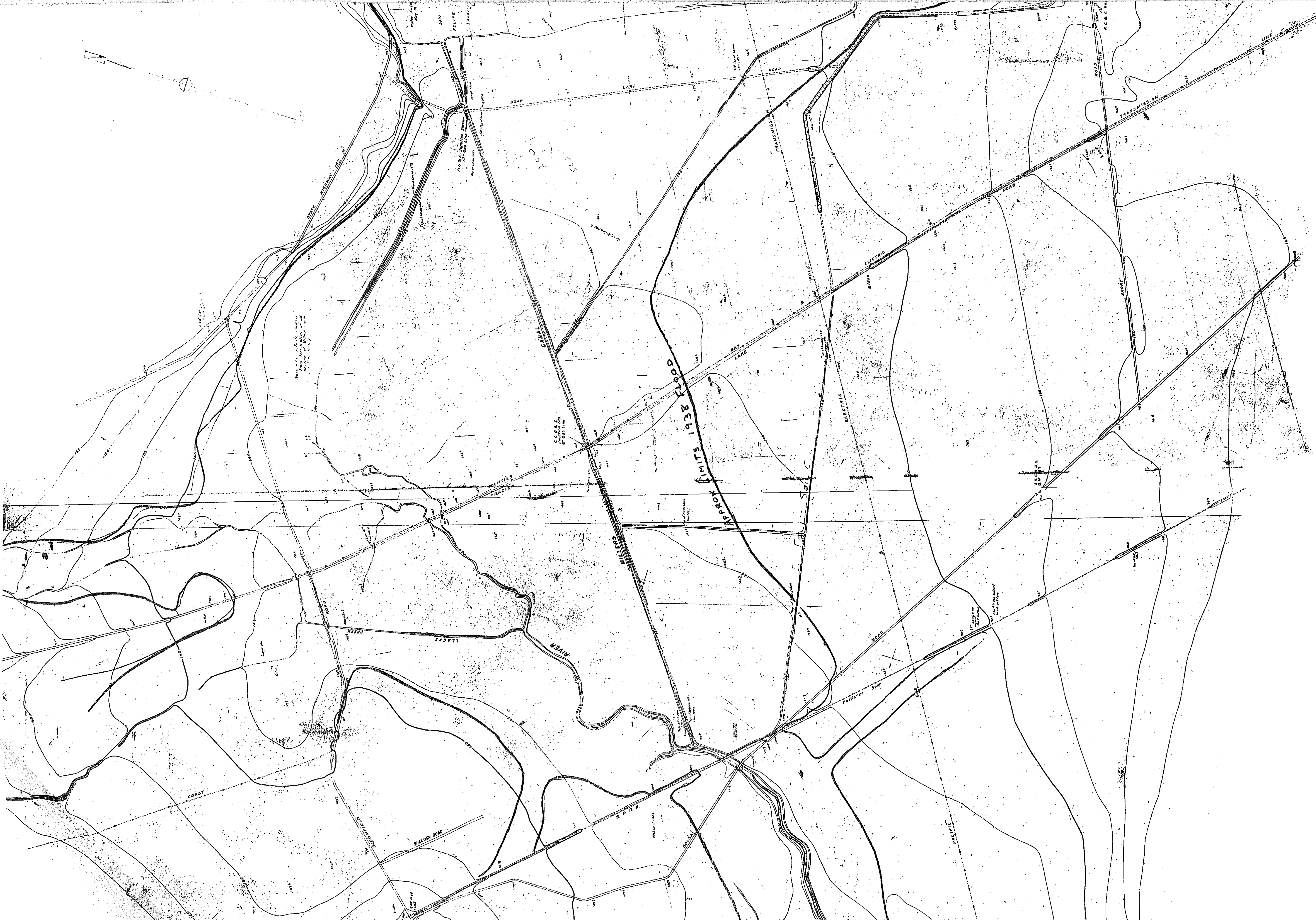
Submitted:

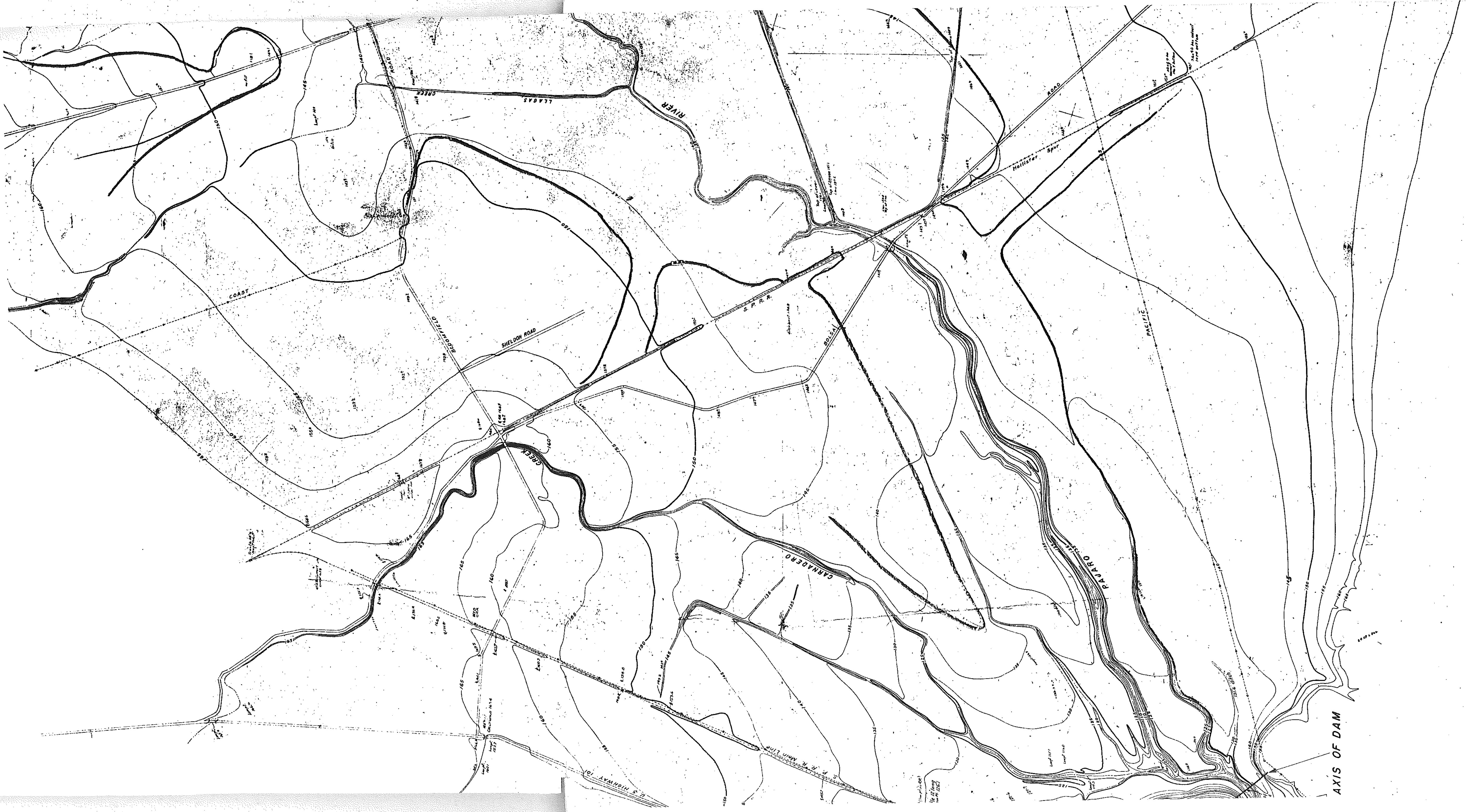
Approved:

Surveyed by H.E.&H.E.S. Engineer

Drawn by H.A.A.

Chief, Civil


Water Surface May 18
SAN FELIPE LAKE
SOAP LAKE ROAD
P.G.&E. Junction Station 12" Gas Line
STATE HIGHWAY 152
TRANSMISSION POLE
ELECTRIC
GAS LAKE
ELECTRIC TRANSMISSION LINE
ROAD
SHORE ROAD
P.G.&E. Gas
C.C.G.&E. Junction Sta. 6" Gas Line
MILLERS CANAL
APPROX LIMITS 1938 FLOOD
Soil
F
COUNTIES
FRAZIER
U.S.C.&G.S. B.M.
PAJARO RIVER
LLAGAS CREEK
ROAD
Hollister Spur
S.P.R.R.
COAST
BLOOMFIELD
SHELDON ROAD
BOLSA
PACIFIC
145
150
155
160


LLAGAS CREEK
RIVER
ROAD
BLOOMFIELD ROAD
SHELDON ROAD
COAST
S.P.R.R.
Hollister Spur
ROAD
PACIFIC
BOLSA
PAJARO
CARNADERO
CREEK
U.S. HIGHWAY 101
S.P.R.R. Main Line
AXIS OF DAM
150
155
160
165

Corps floodplain delineation; however, the event frequency associated with each delineation was changed based on the results of the HEC-2 flood profiles. The 100-year floodplain was changed to a 50-year, the 50-year changed to a 25-year and the 25-year changed to a 12-year event. As a result, there is considerably more flooded acres for a given event and is one of the main reasons why the average annual damage values in this report are higher than those developed by the Corps.

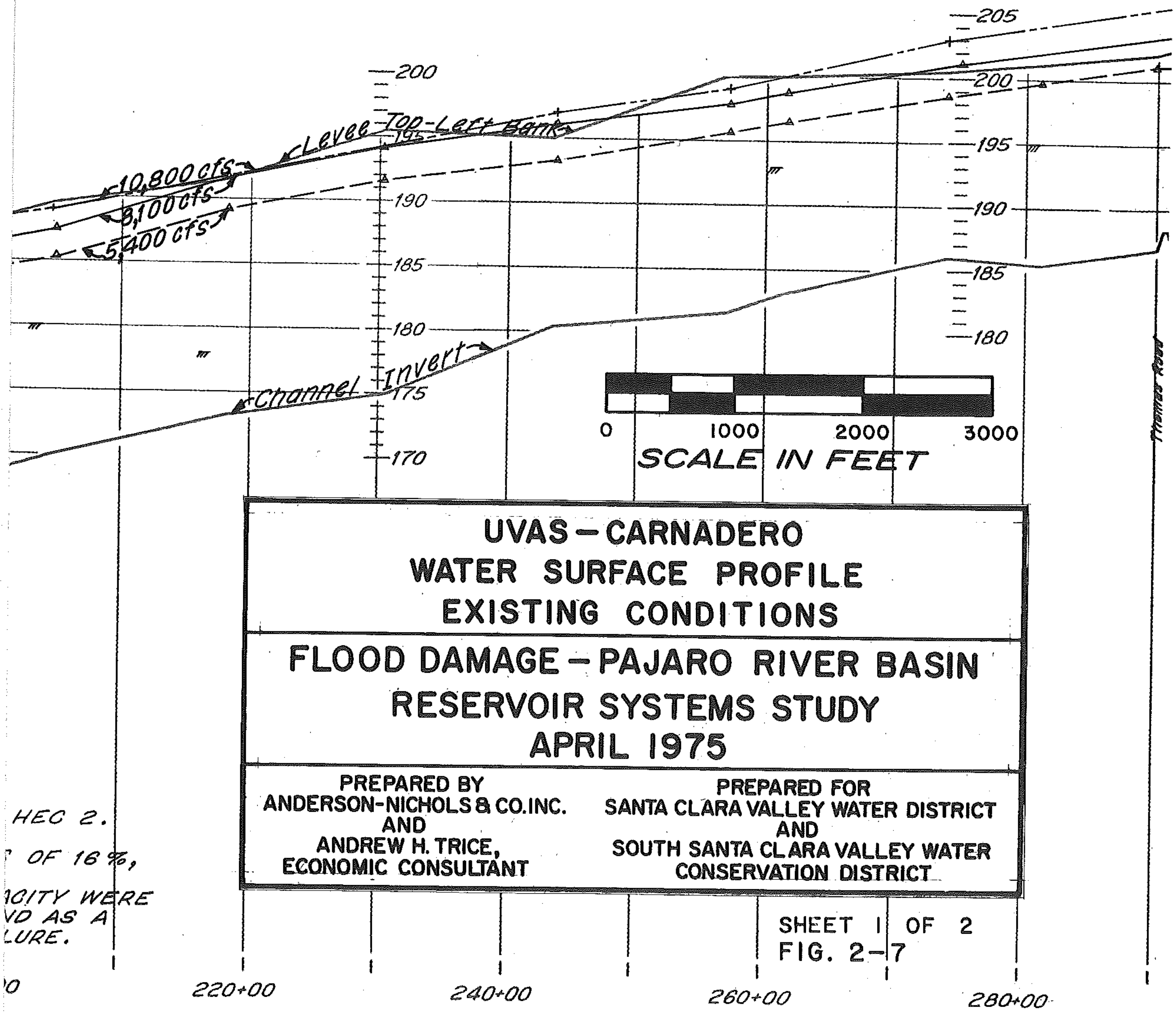
Complete sets of water surface profiles were computed for two different geometries: 1) with flow confined within levees and 2) with flow allowed in areas adjoining the creek channel and with the same water surface elevation as that within the channels. This latter condition approaches the overland flood flow situation when levees are breached, and this information contributed to delineation of the revised floodplain. The results of these analyses are shown in Appendices A-12 and A-13. Figures 2-7 and 2-8 provide channel and levee elevations and water surface profiles for selected flow rates. Although the Corps' analyses neglected flood damages in the reach of Uvas Creek designated Reach VII, there are 70 homes and 3 major highways and roads and bridges that are inundated or destroyed by the larger flood events. The extent of flood flows in this reach from Hecker Pass upstream to Uvas Dam is presented in Figures 2-9 through 2-20.

LEVEE FAILURE - HEC GRADUALLY VARIED UNSTEADY FLOW MODEL

An investigation of potential levee failure on the Gilroy side of Uvas-Carnadero Creek was performed in order to determine expected damages in the area affected by flood flows originating from a failure. The HEC-2 runs discussed previously, provided information leading to the location of low points in the levee system, where the most serious overtopping is likely to occur. A point north of Miller Road (between HEC-2 cross sections 475 and 483, see Appendix A-12), was used during the analysis.

Based on channel capacity, it was assumed that 9,000 cfs is the maximum discharge which would flow overland upon levee failure. It was also assumed that the levee would fail progressively as the water velocity scoured an increasing breach area until the tractive force was no longer exceeded.

In order to approximate this physical condition, the cross section geometry at the levee was configured to create reasonable velocity values with elevation head at the levels expected in this area of the levee. The levee break cross-section at fully developed failure was assumed to be a 150-foot wide rectangular break with a bottom elevation of 115 feet. At elevation 118 feet the cross section was assumed to increase to a 1,150-foot width in order to provide sufficient area for the continuity equation with expected scour velocities. This approximates the actual condition where a deep hole is scoured which develops the required additional area.



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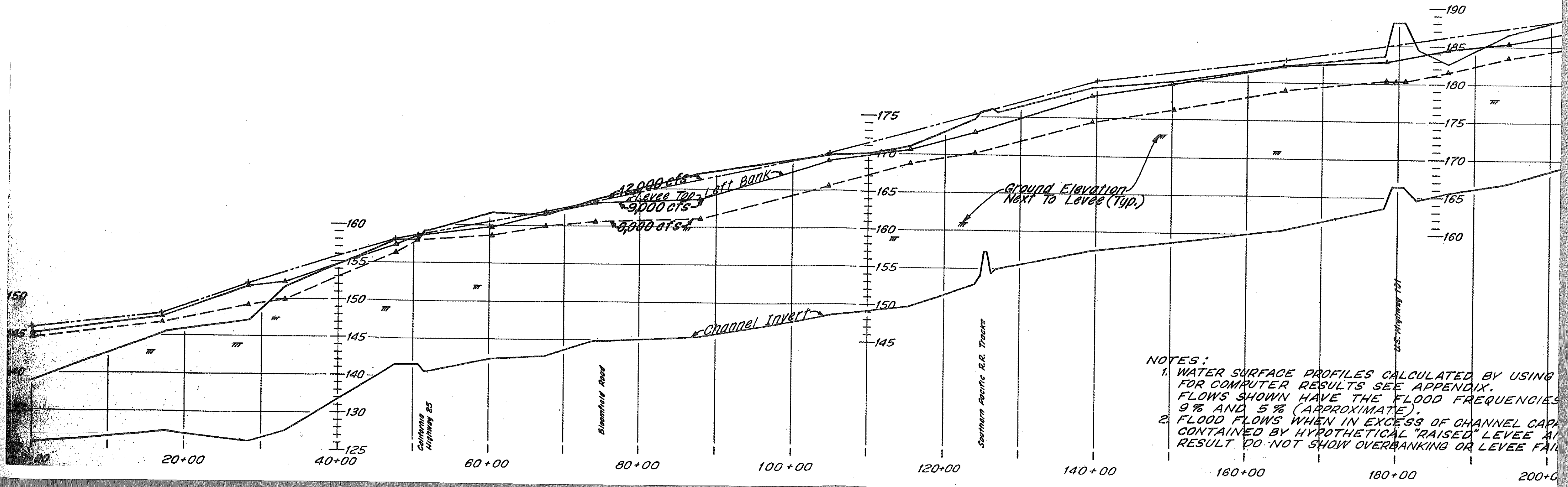
UVAS — CARNADERO
WATER SURFACE PROFILE
EXISTING CONDITIONS

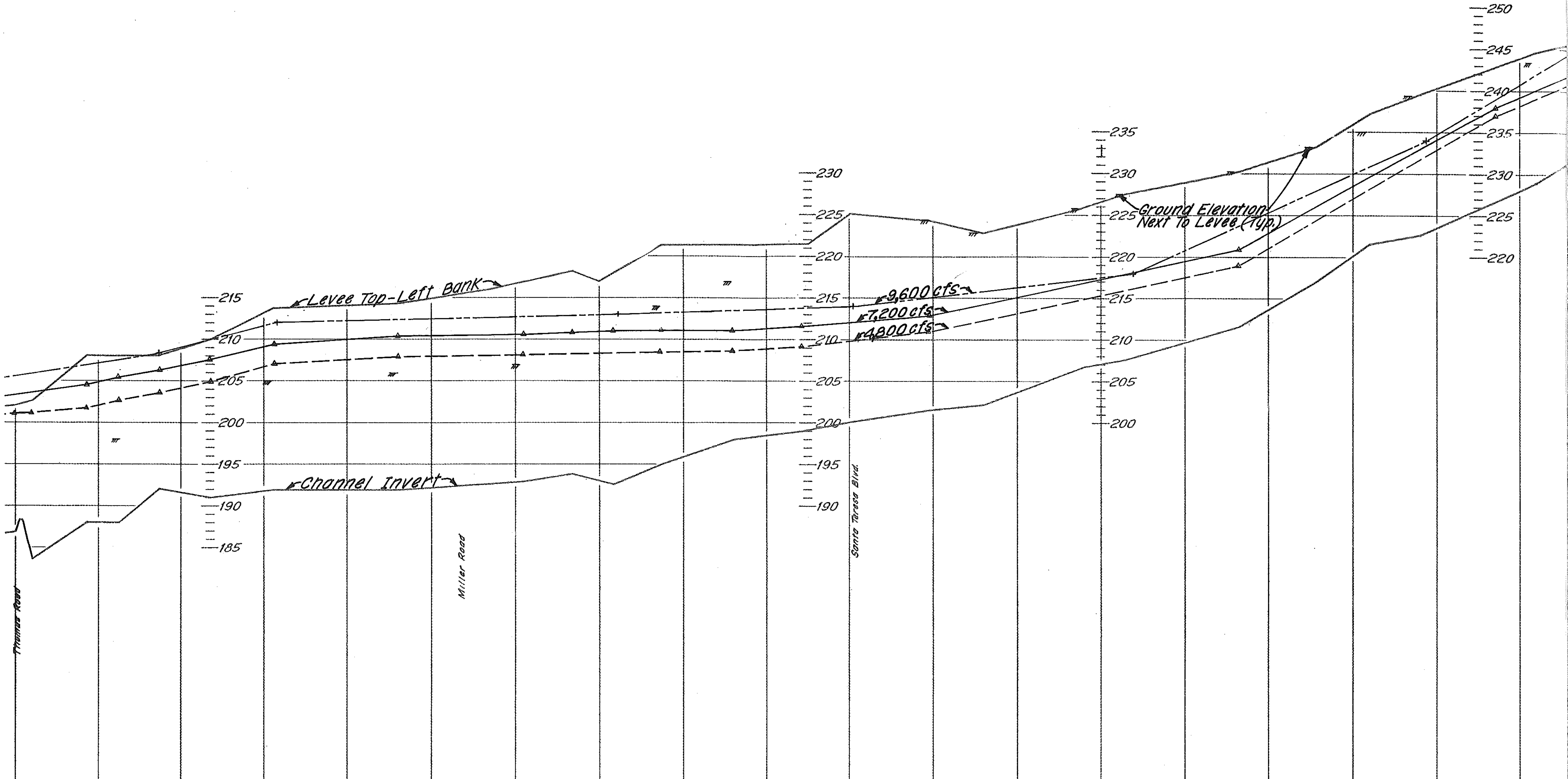
FLOOD DAMAGE — PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

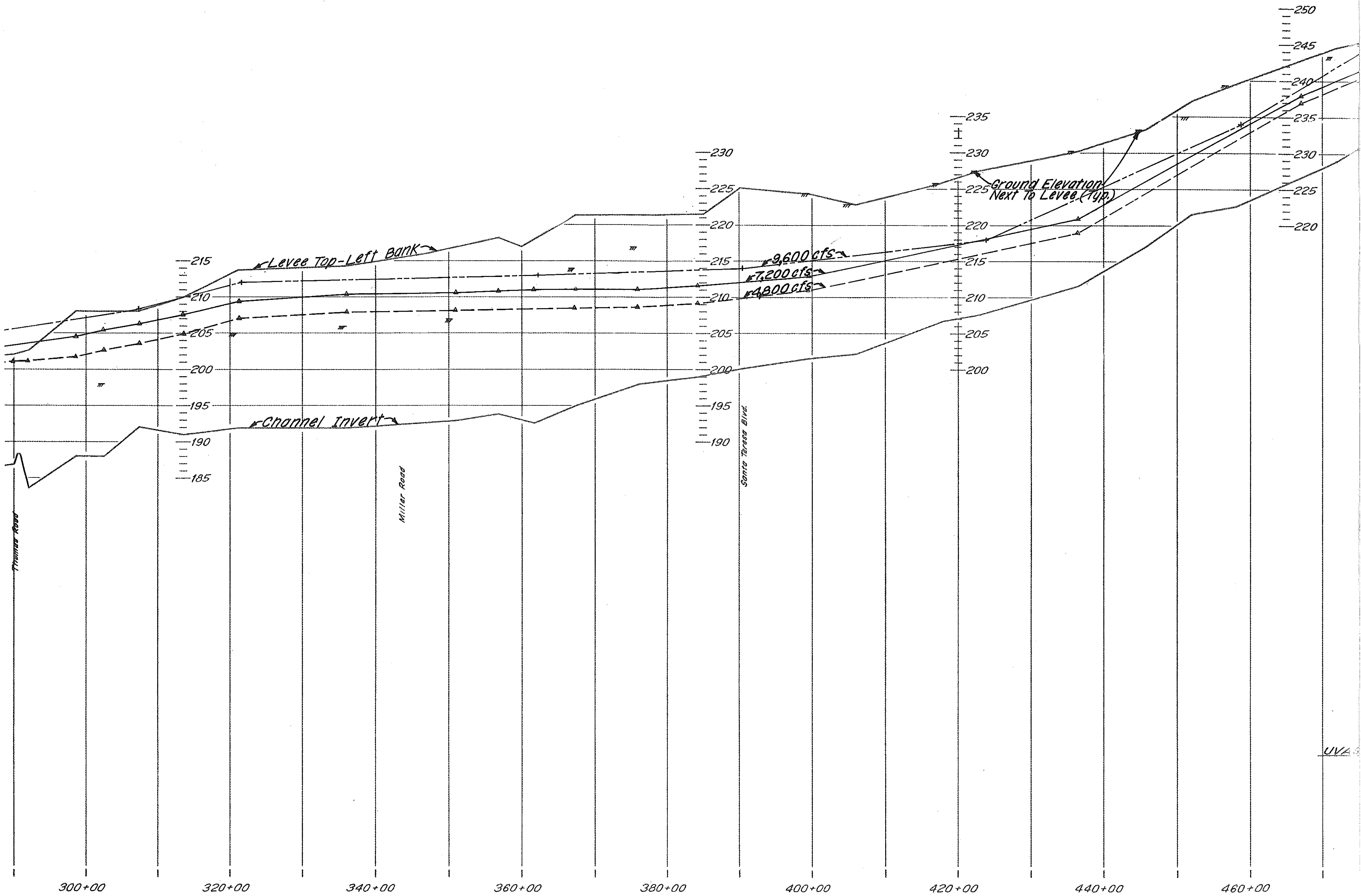
SHEET 1 OF 2
FIG. 2-7



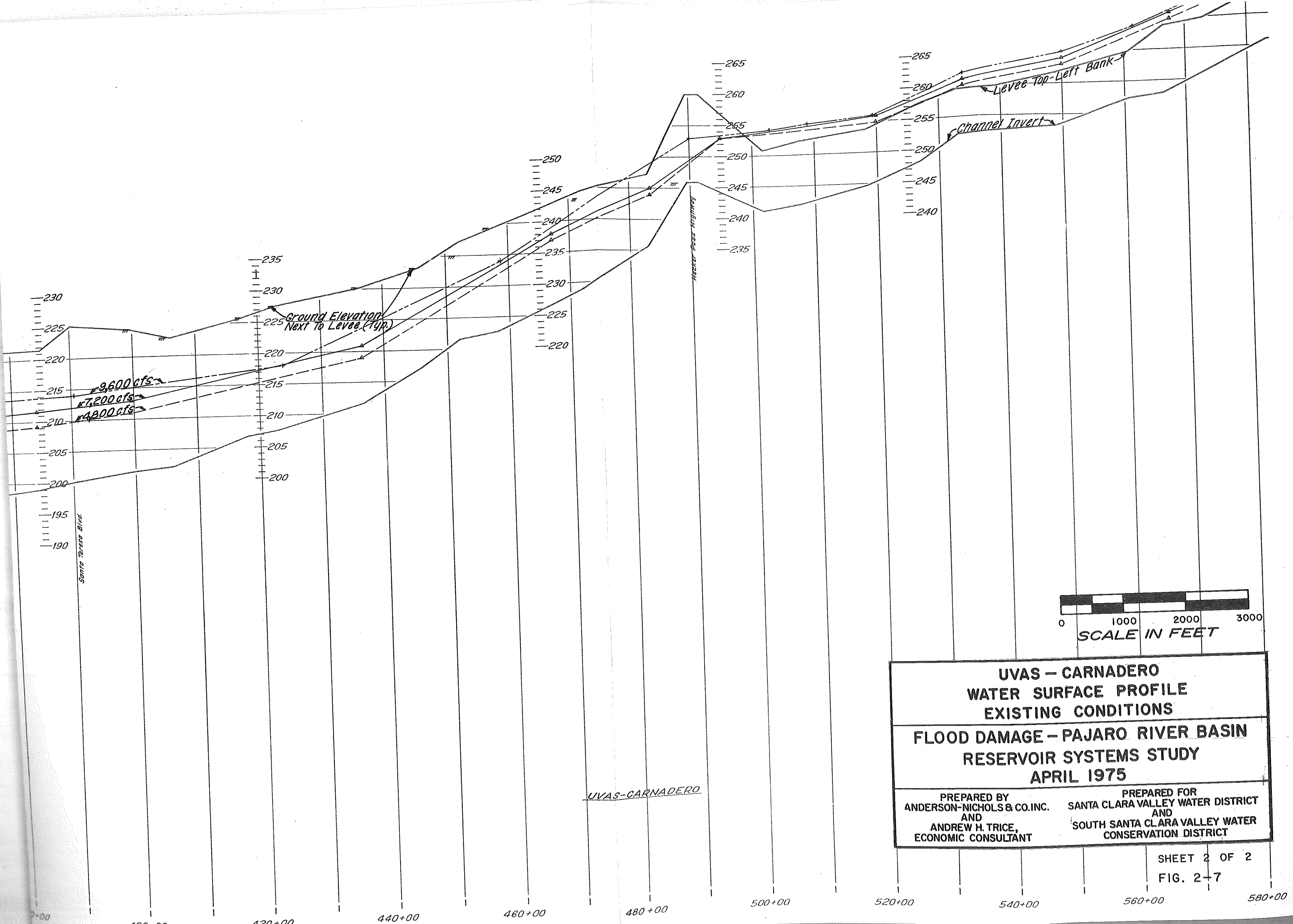
NOTES:
1. WATER SURFACE PROFILES CALCULATED BY USING
FOR COMPUTER RESULTS SEE APPENDIX.
FLOWS SHOWN HAVE THE FLOOD FREQUENCIES
9% AND 5% (APPROXIMATE).
2. FLOOD FLOWS WHEN IN EXCESS OF CHANNEL CAP
CONTAINED BY HYPOTHETICAL "RAISED" LEVEE A
RESULT DO NOT SHOW OVERBANKING OR LEVEE FAI



Levee Top-Left Bank
Channel Invert
9,600 cfs
7,200 cfs
4,800 cfs
Ground Elevation Next To Levee (Typ.)
Thomas Road
Miller Road
Santa Teresa Blvd.


Levee Top-Left Bank
Channel Invert
9,600 cfs
7,200 cfs
4,800 cfs
Ground Elevation Next To Levee (Typ.)
Thomas Road
Miller Road
Santa Teresa Blvd.
185
190
195
200
205
210
215
220
225
230
235
240
245
250
300+00
320+00
340+00
360+00
380+00
400+00
420+00
440+00
460+00

UVA



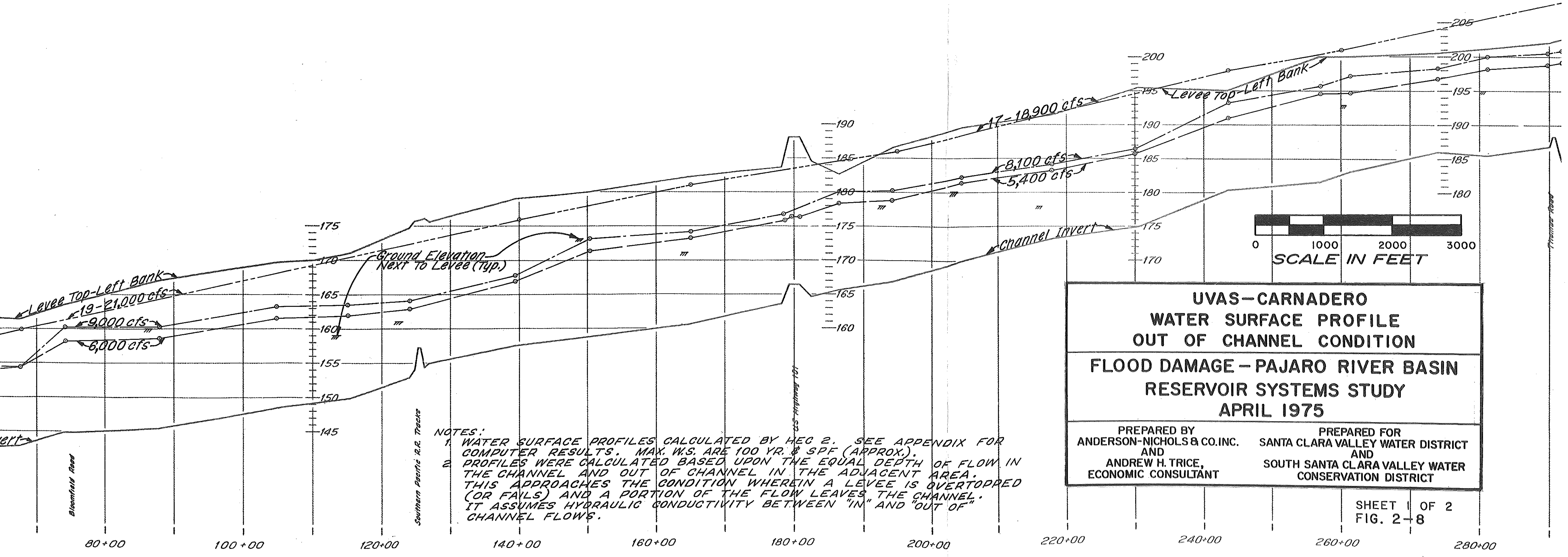
UVAS – CARNADERO
WATER SURFACE PROFILE
EXISTING CONDITIONS

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

SHEET 2 OF 2

FIG. 2-7



NOTES:
1. WATER SURFACE PROFILES CALCULATED BY HEC 2. SEE APPENDIX FOR COMPUTER RESULTS. MAX. W.S. ARE 100 YR. & SPF (APPROX.).
2. PROFILES WERE CALCULATED BASED UPON THE EQUAL DEPTH OF FLOW IN THE CHANNEL AND OUT OF CHANNEL IN THE ADJACENT AREA. THIS APPROACHES THE CONDITION WHEREIN A LEVEE IS OVERTOPPED (OR FAILS) AND A PORTION OF THE FLOW LEAVES THE CHANNEL. IT ASSUMES HYDRAULIC CONDUCTIVITY BETWEEN "IN" AND "OUT OF" CHANNEL FLOWS.

UVAS—CARNADERO
WATER SURFACE PROFILE
OUT OF CHANNEL CONDITION

FLOOD DAMAGE—PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO.INC.
AND
ANDREW H. TRICE,
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT

SHEET 1 OF 2
FIG. 2-8

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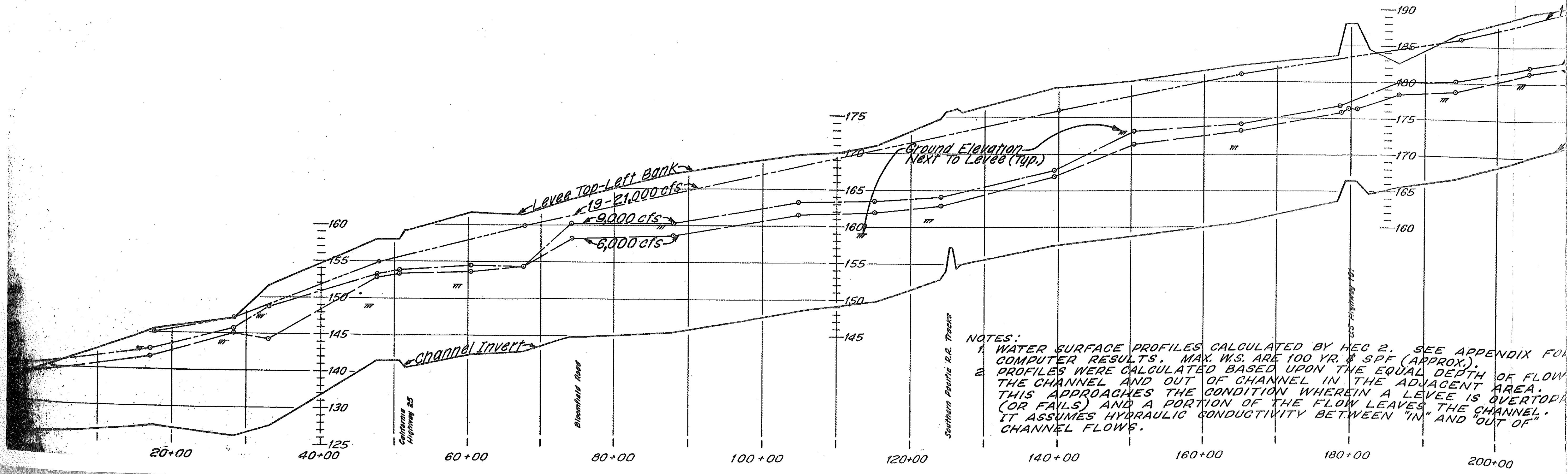
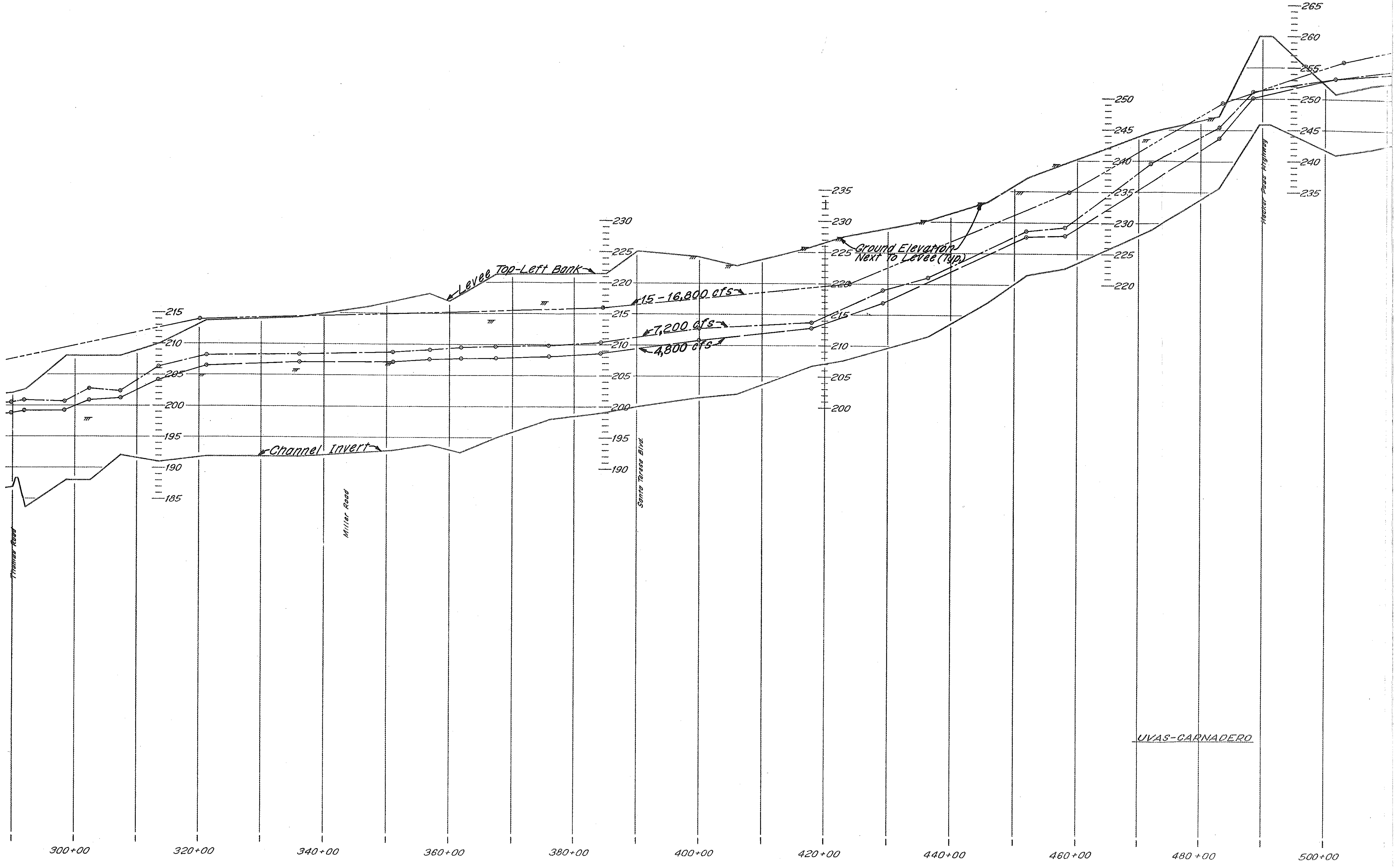
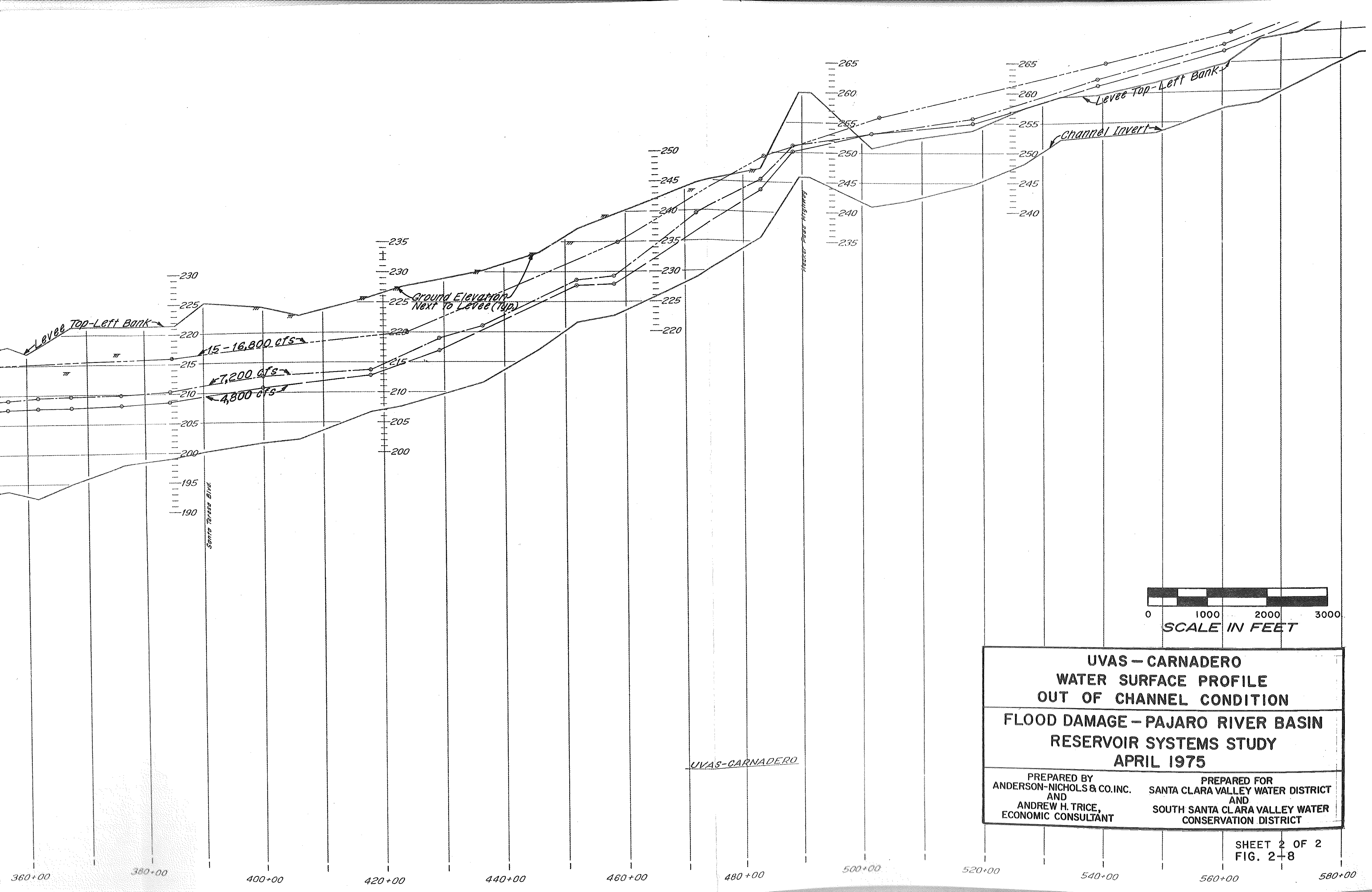


NOTES:
1. WATER SURFACE PROFILES CALCULATED BY HEC 2. SEE APPENDIX FO COMPUTER RESULTS. MAX. W.S. ARE 100 YR. & SPF (APPROX.).
2. PROFILES WERE CALCULATED BASED UPON THE EQUAL DEPTH OF FLOW THE CHANNEL AND OUT OF CHANNEL IN THE ADJACENT AREA. THIS APPROACHES THE CONDITION WHEREIN A LEVEE IS OVERTOPP (OR FAILS) AND A PORTION OF THE FLOW LEAVES THE CHANNEL. IT ASSUMES HYDRAULIC CONDUCTIVITY BETWEEN "IN" AND "OUT OF" CHANNEL FLOWS.


Levee Top-Left Bank
Ground Elevation Next To Levee (Typ.)
15 - 16,800 cfs
7,200 cfs
4,800 cfs
Channel Invert
Thomas Road
Miller Road
Santa Teresa Blvd.
Hecker Pass Highway
185
190
195
200
205
210
215
220
225
230
235
240
245
250
255
260
265
300+00
320+00
340+00
360+00
380+00
400+00
420+00
440+00
460+00
480+00
500+00
UVAS-CARNADERO



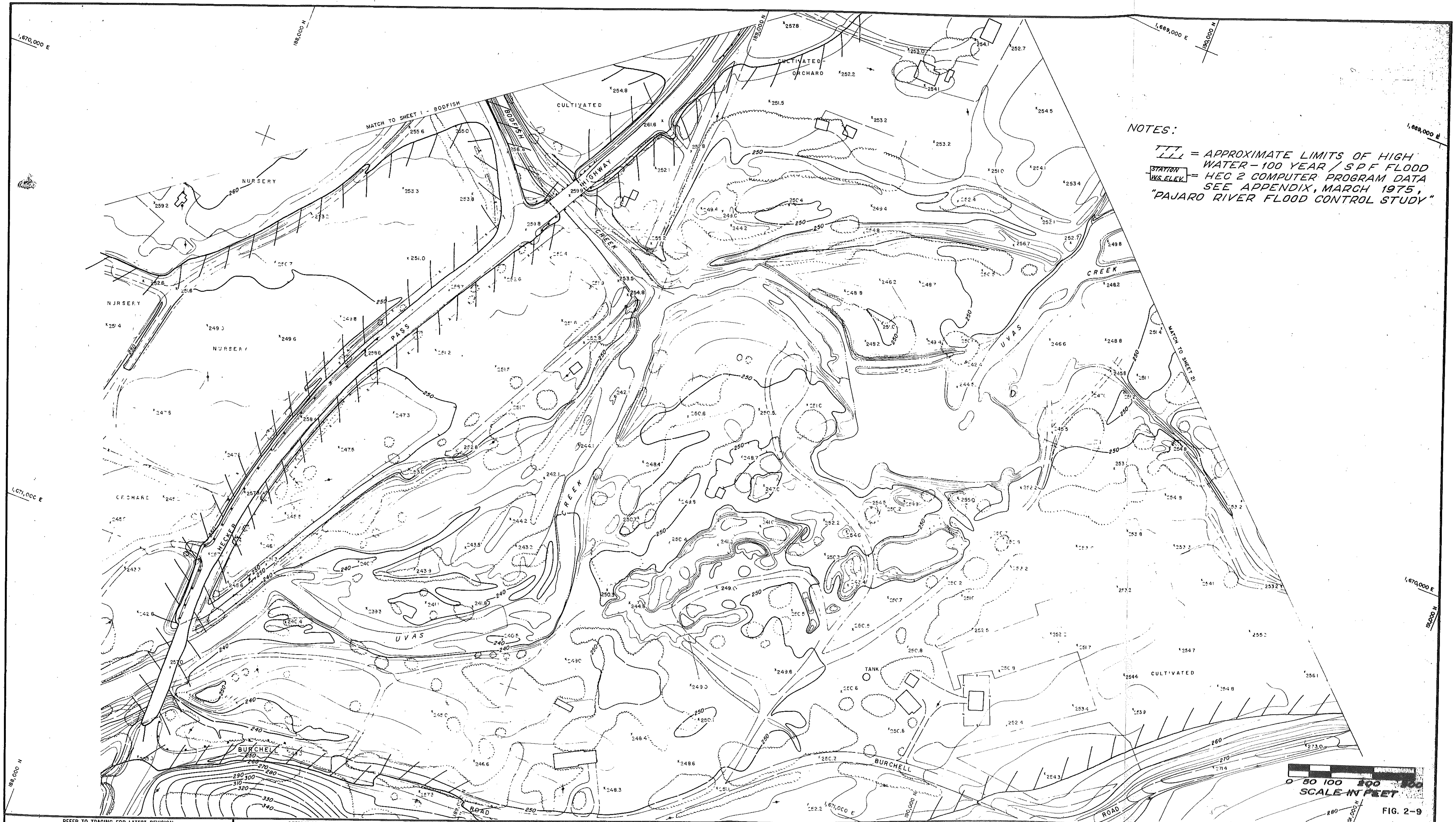
UVAS – CARNADERO
WATER SURFACE PROFILE
OUT OF CHANNEL CONDITION

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO.INC.
AND
ANDREW H. TRICE,
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT

SHEET 2 OF 2
FIG. 2-8



NOTES:

▨ = APPROXIMATE LIMITS OF HIGH WATER – 100 YEAR / S P F FLOOD

STATION / WS. ELEV. = HEC 2 COMPUTER PROGRAM DATA SEE APPENDIX, MARCH 1975, "PAJARO RIVER FLOOD CONTROL STUDY"

FIG. 2–9

REFER TO TRACING FOR LATEST REVISION			
REV.	DESCRIPTION	SUB.	APPR.

JOB NO. 4246

REFERENCE INFORMATION AND NOTES

DATE OF PHOTOGRAPHY: MARCH 20, 1974 6" F.L.

BASE MAP PREPARED BY Towill, Inc

FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO. INC.
AND
ANDREW H. TRICE
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

DATE
DESIGN W.M.R.
DRAWN F.S.W.
CHECKED

Santa Clara Valley Water District

ENGINEERING CERTIFICATION

PROJECT ENGINEER

DIVISION ENGINEER R.C.E. NO. 16684

ENGINEERING APPROVAL

HEAD, PROJECT DEVELOPMENT BRANCH R.C.E. NO. 17646

MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 20 OF 31

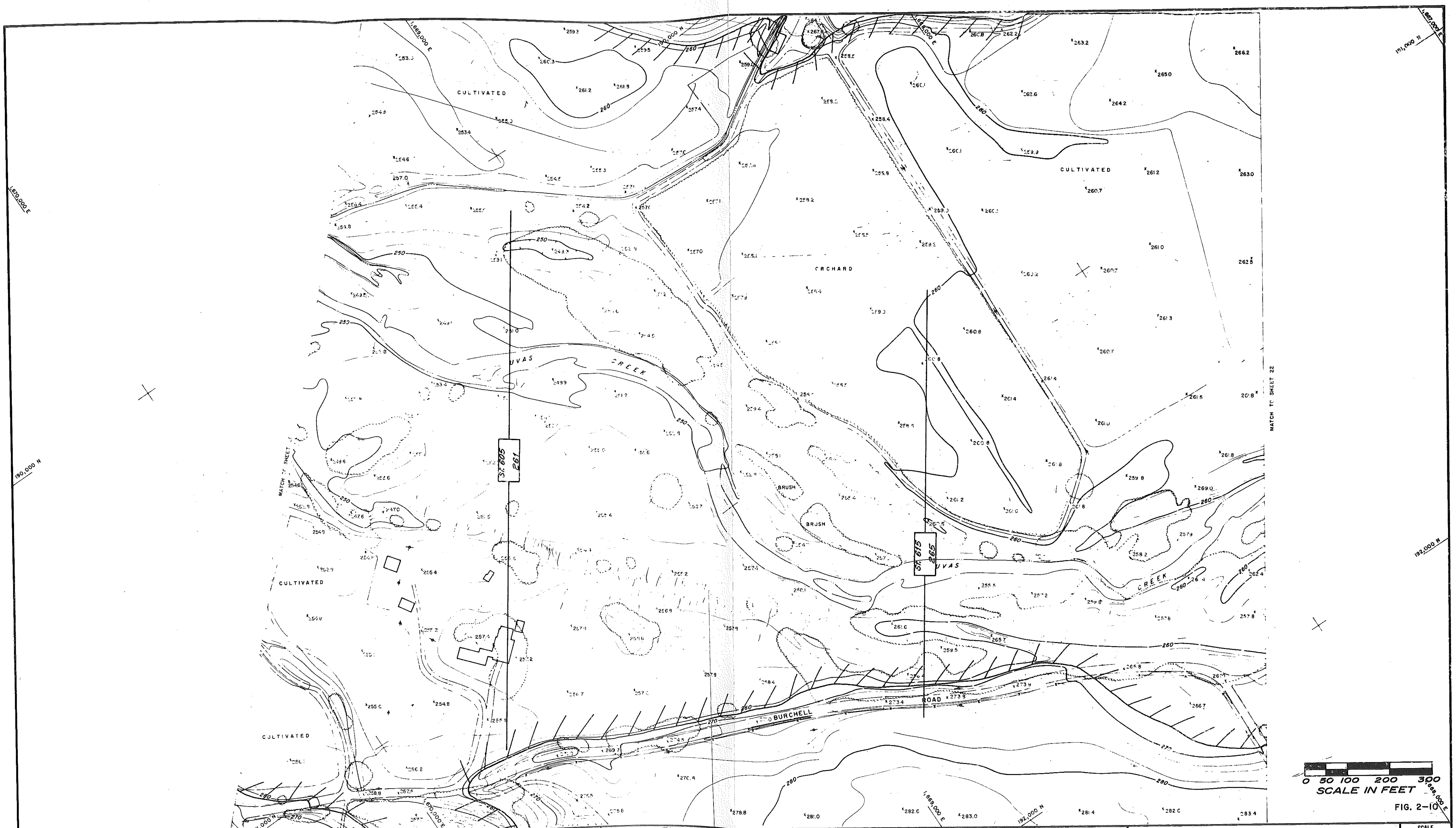


FIG. 2-10

REFER TO TRACING FOR LATEST REVISION

REV.	DESCRIPTION	SUB.	APPR.

JOB NO. 4246

REFERENCE INFORMATION AND NOTES

▨ = APPROXIMATE LIMITS OF HIGH WATER – 100 YEAR /SPF FLOOD.

DATE OF PHOTOGRAPHY: MARCH 20,1974 6" F.L.

BASE MAP PREPARED BY Towill, Inc.

FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO. INC.
AND
ANDREW H. TRICE
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

DATE

DESIGN W.M.R.

DRAWN F.S.W.

CHECKED

Santa Clara Valley Water District

ENGINEERING CERTIFICATION

PROJECT ENGINEER

DIVISION ENGINEER R.C.E. NO. 16684

ENGINEERING APPROVAL

HEAD, PROJECT DEVELOPMENT BRANCH R.C.E. NO. 17646

MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) **PROJECT NO. 5018**

UVAS - CARNADERO CREEK

SCALE

SHEET 21 OF 31

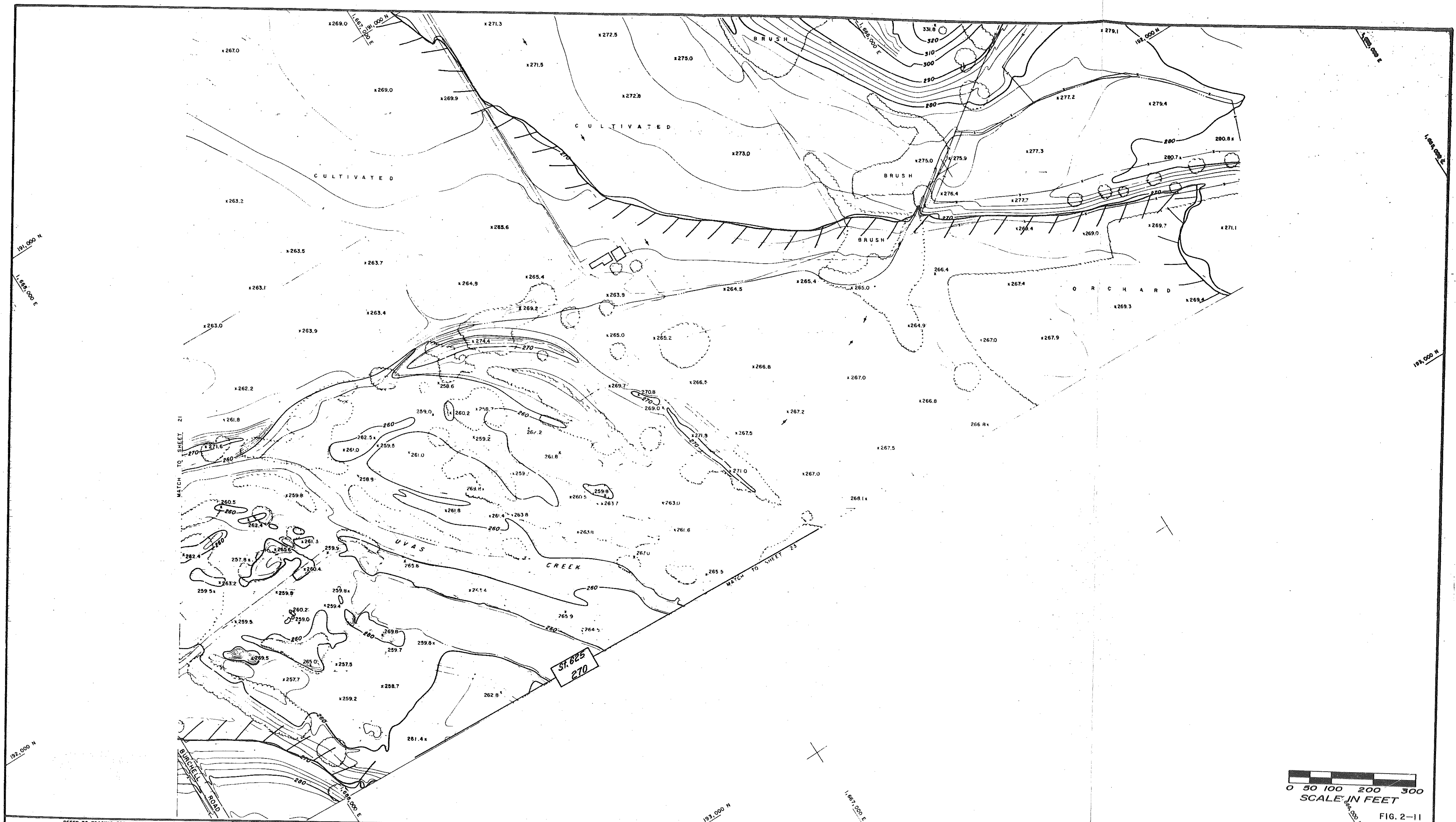


FIG. 2—11

REFER TO TRACING FOR LATEST REVISION

REV.	DESCRIPTION	SUB.	APPR.

JOB NO. 4248

REFERENCE INFORMATION AND NOTES

▨ = APPROXIMATE LIMITS OF HIGH WATER—100 YEAR /SPF FLOOD

DATE OF PHOTOGRAPHY: MARCH 20, 1974 6" F.L.

BASE MAP PREPARED BY Towill, inc

FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO. INC.
AND
ANDREW H. TRICE
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT

DATE

DESIGN W.M.R.

DRAWN F.S.W.

CHECKED

Santa Clara Valley Water District

ENGINEERING CERTIFICATION

PROJECT ENGINEER

DIVISION ENGINEER R.C.E. NO. 16684

ENGINEERING APPROVAL

HEAD, PROJECT DEVELOPMENT BRANCH R.C.E. NO. 17646

MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 22 OF 31

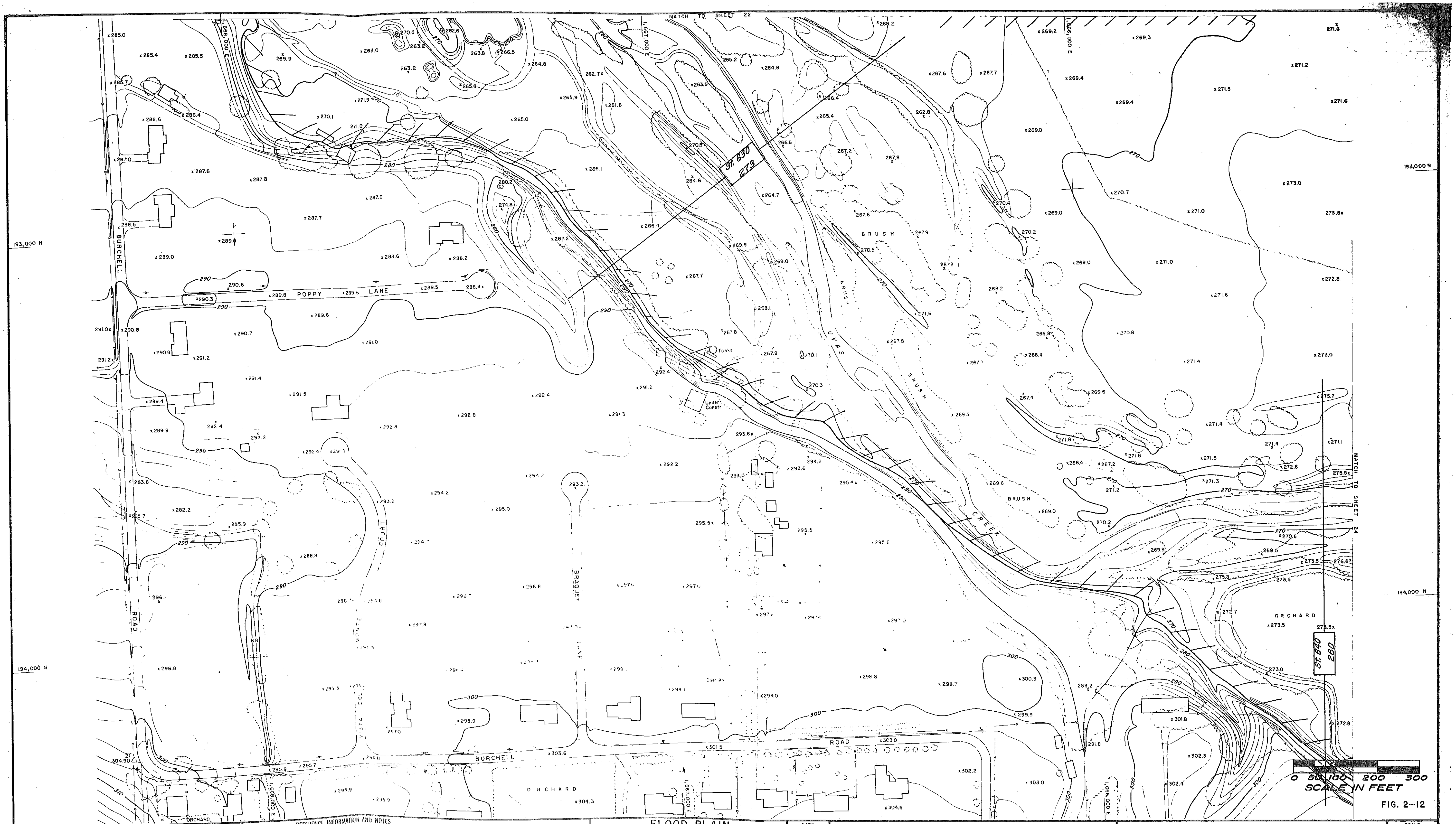


FIG. 2–12

REFER TO TRACING FOR LATEST REVISION

REV.	DESCRIPTION	SUB.	APPR.

REFERENCE INFORMATION AND NOTES

▨ = APPROXIMATE LIMITS OF HIGH WATER–100 YEAR /SPF FLOOD.

DATE OF PHOTOGRAPHY: MARCH 20,1974 6" F.L.

BASE MAP PREPARED BY Towill, Inc.

FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO INC.
AND
ANDREW H. TRICE
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

DATE
DESIGN W.M.R.
DRAWN F.S.W.
CHECKED

Santa Clara Valley Water District

ENGINEERING CERTIFICATION
PROJECT ENGINEER
DIVISION ENGINEER R.C.E. NO. 16684

ENGINEERING APPROVAL
HEAD, PROJECT DEVELOPMENT BRANCH R.C.E. NO. 17646

MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE
SHEET 23 OF 31

JOB NO. 4246

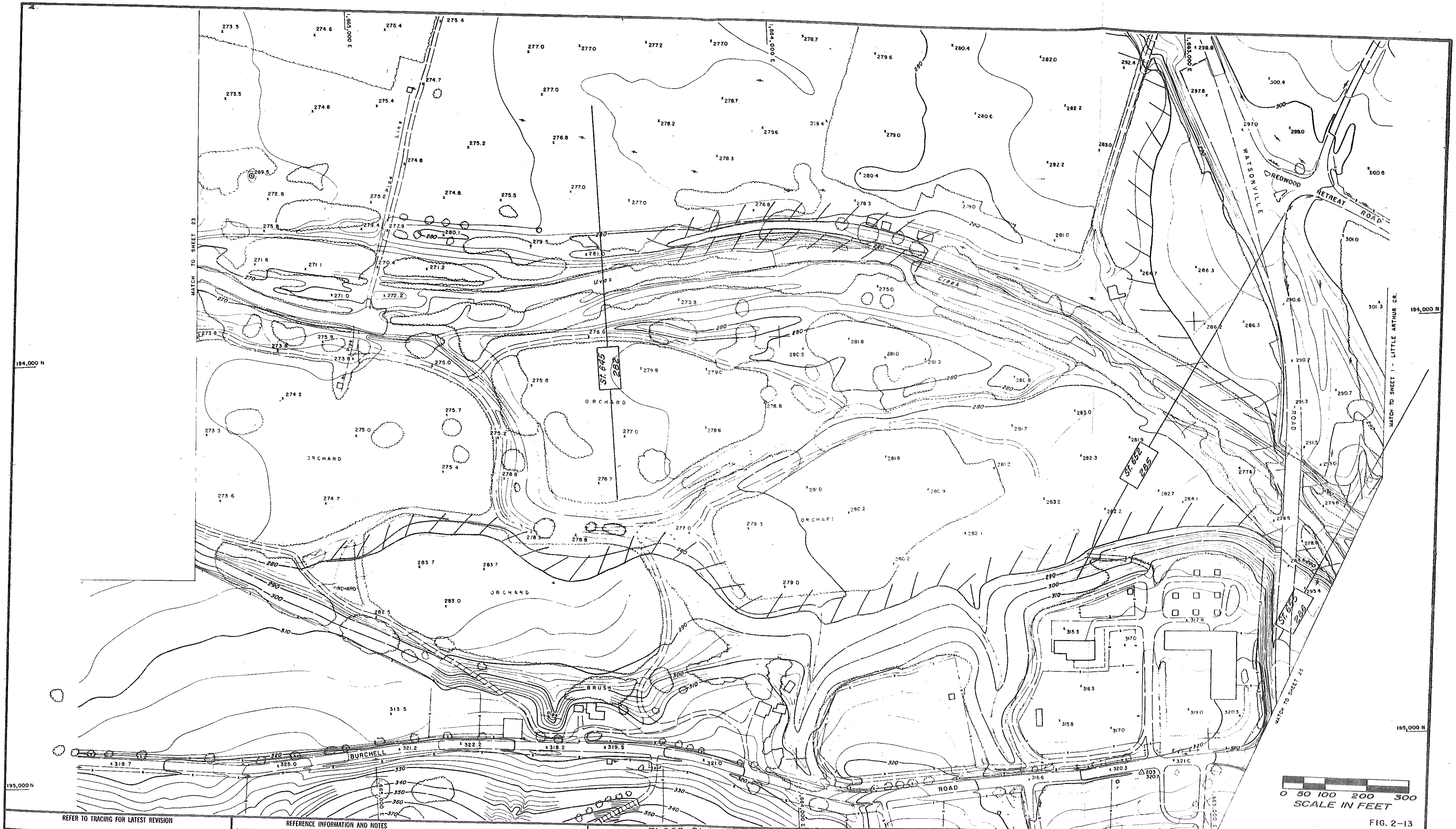


FIG. 2-13

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DATE OF PHOTOGRAPHY: MARCH 20,1974 6" F.L.

BASE MAP PREPARED BY Towill, Inc.

FLOOD PLAIN

FLOOD DAMAGE - PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO. INC.
AND
ANDREW H. TRICE
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER
CONSERVATION DISTRICT

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MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) **PROJECT NO. 5018**

UVAS - CARNADERO CREEK

SCALE
SHEET 24ᐟ OF 31

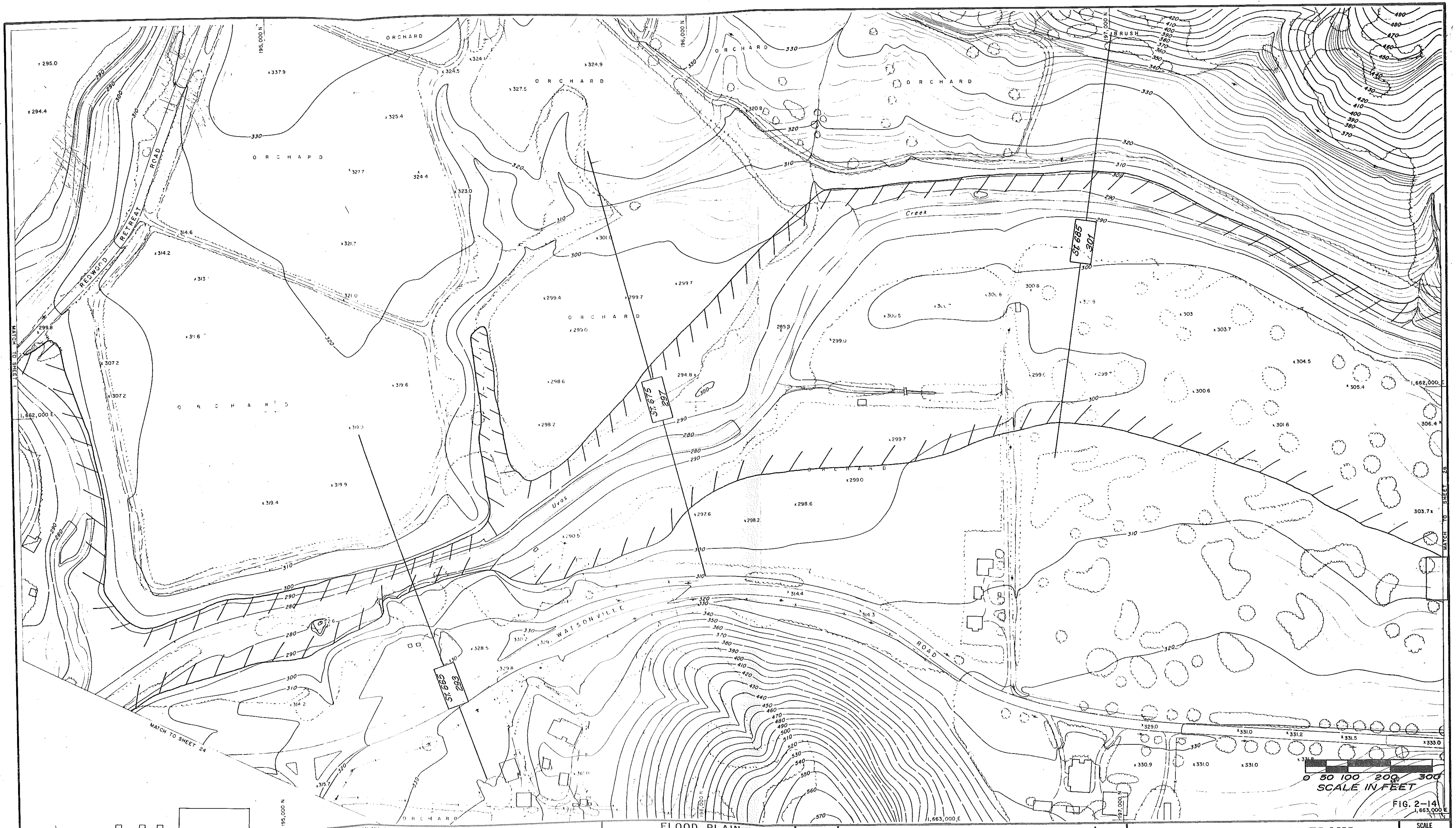

FIG. 2–14

REFERENCE INFORMATION AND NOTES

▨ = APPROXIMATE LIMITS OF HIGH WATER–100 YEAR /SPF FLOOD.

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BASE MAP PREPARED BY [illegible]

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MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 25 OF 31

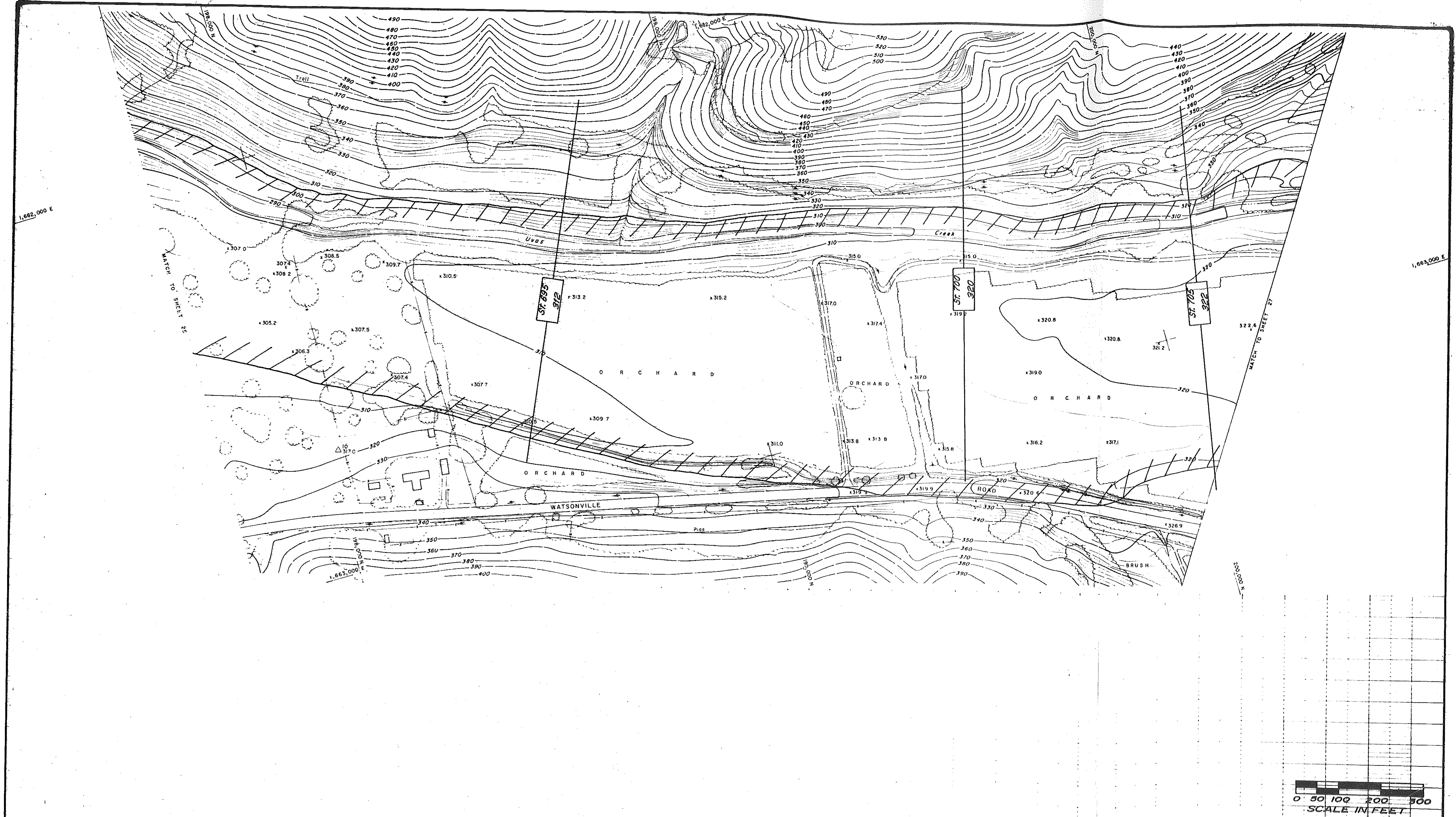

FIG. 2–15

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MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 26 OF 31

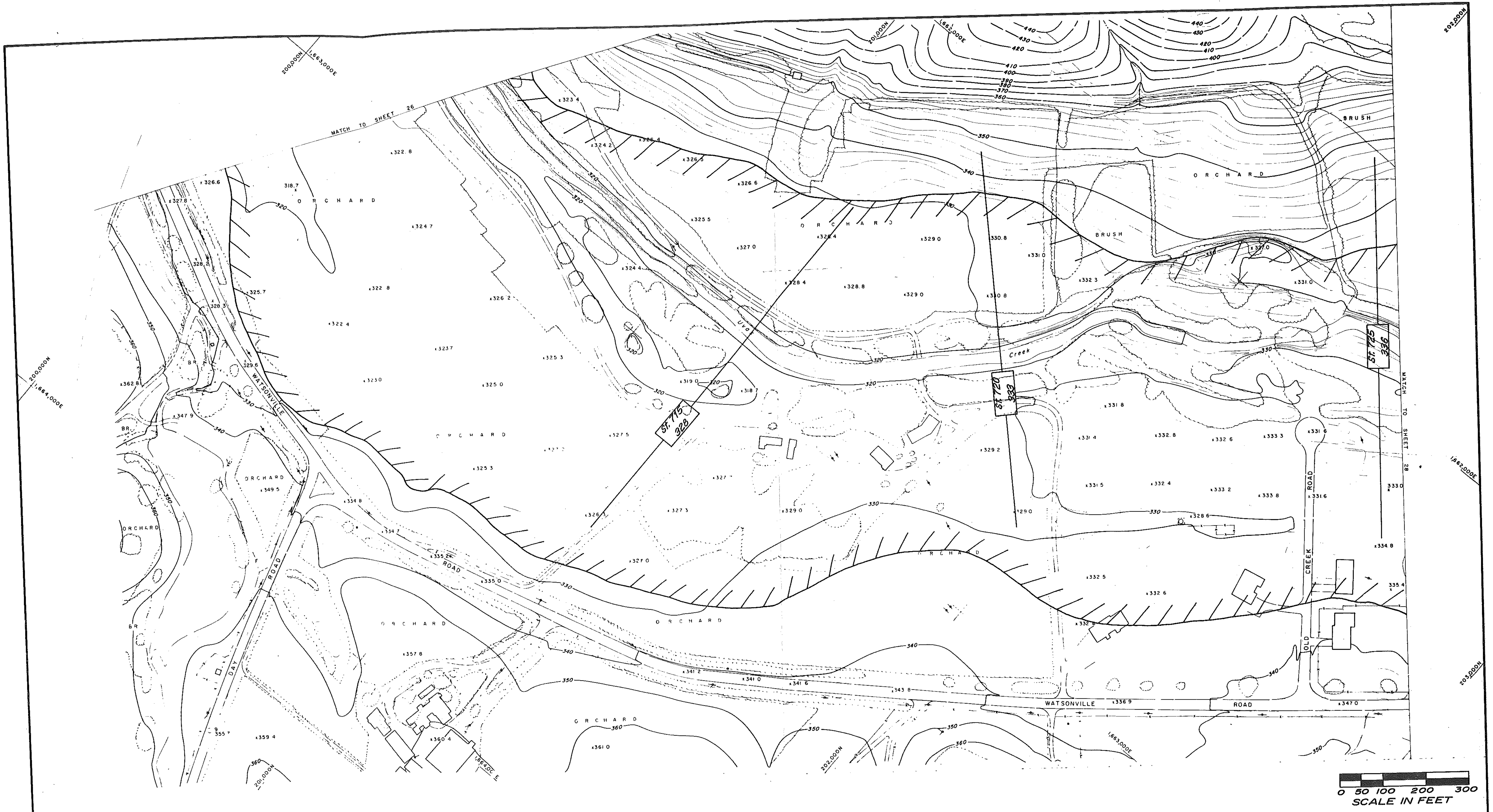

FIG. 2–16

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FLOOD PLAIN

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RESERVOIR SYSTEMS STUDY
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ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 27 OF 31

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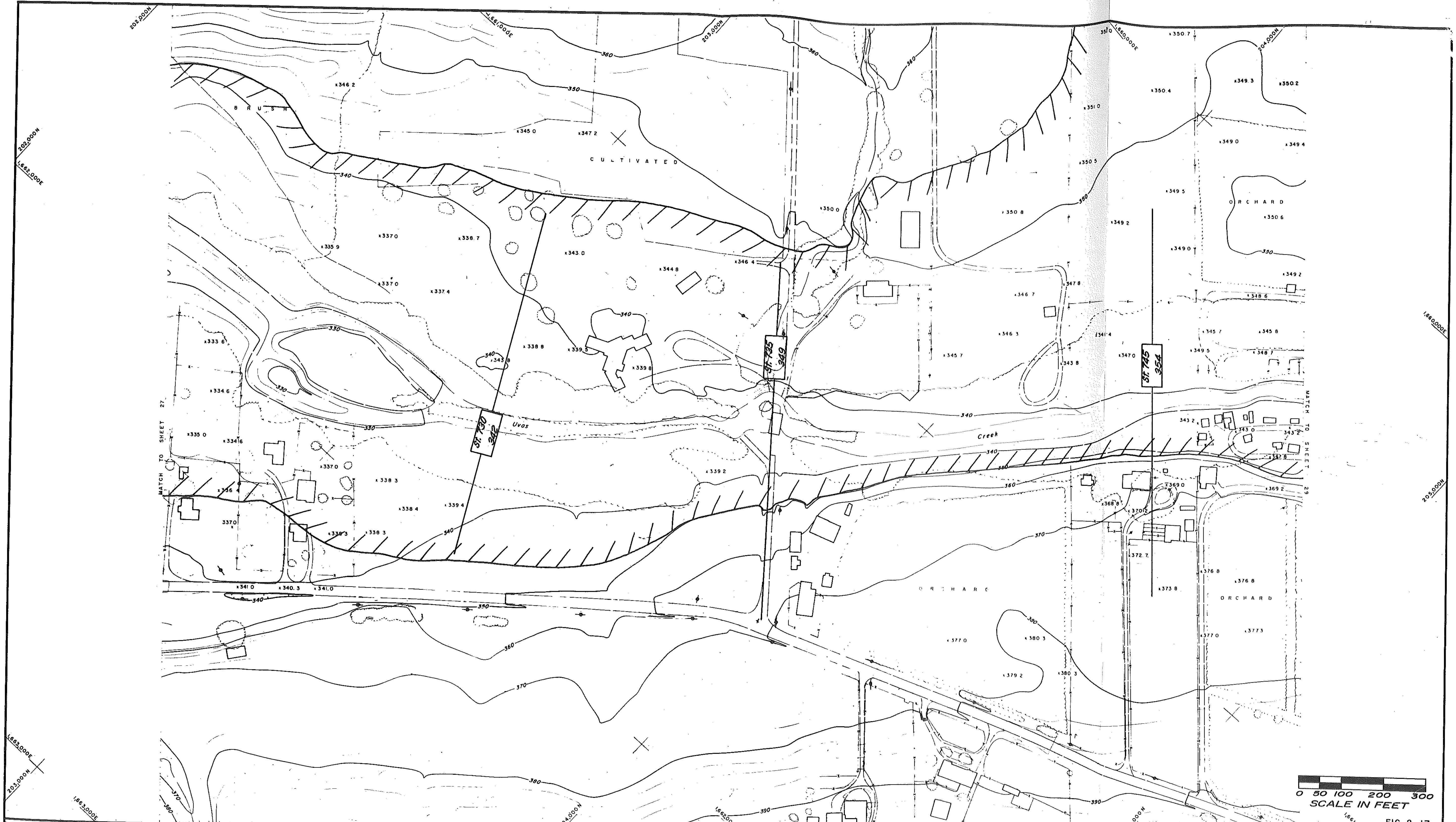

FIG. 2-17

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MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 28 OF 31

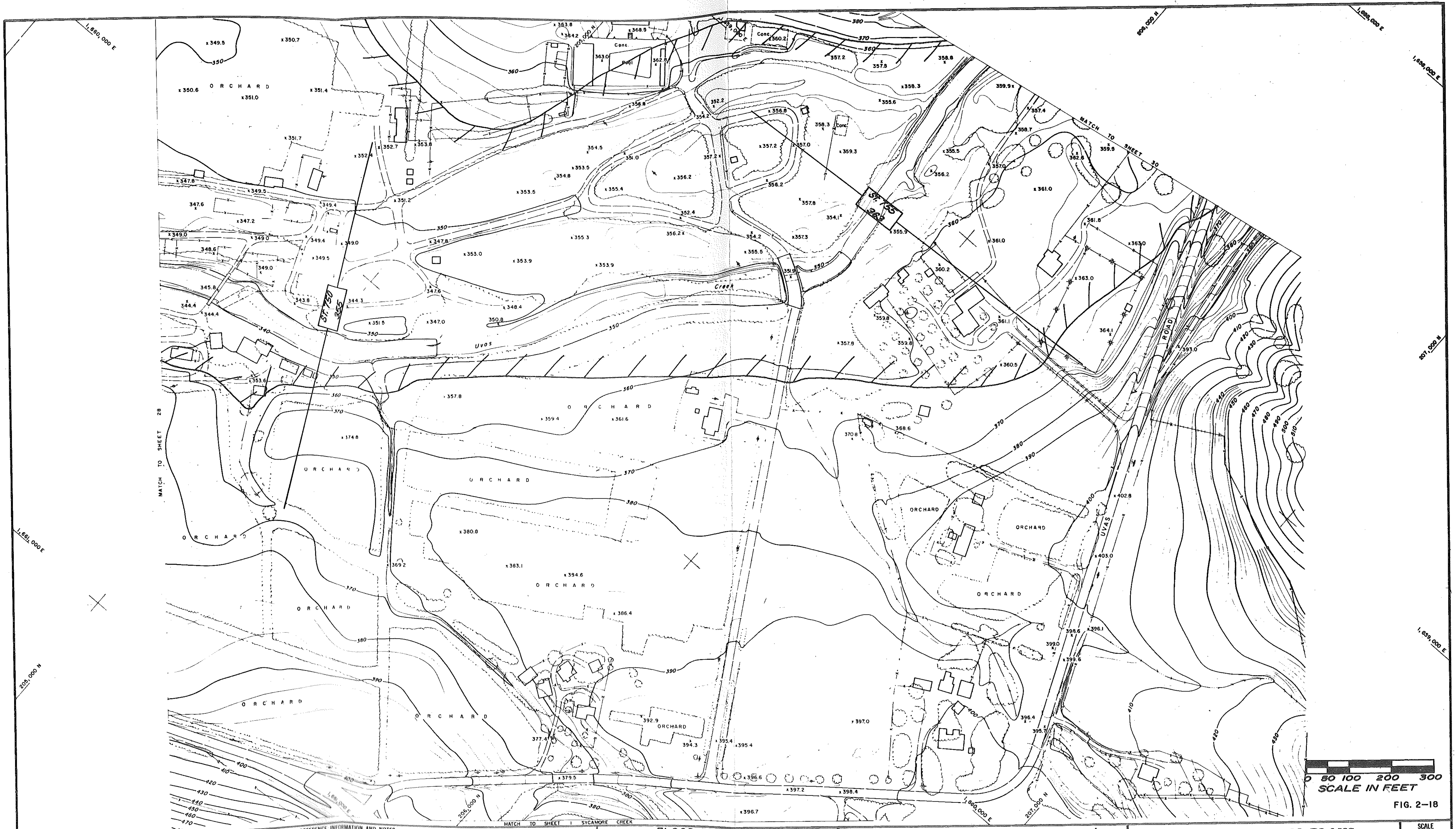

FIG. 2–18

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DATE OF PHOTOGRAPHY: MARCH 23, 1974 6" F.L.

BASE MAP PREPARED BY towill, inc

FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

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MAP AND GENERAL PLANS

ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 29 OF 31

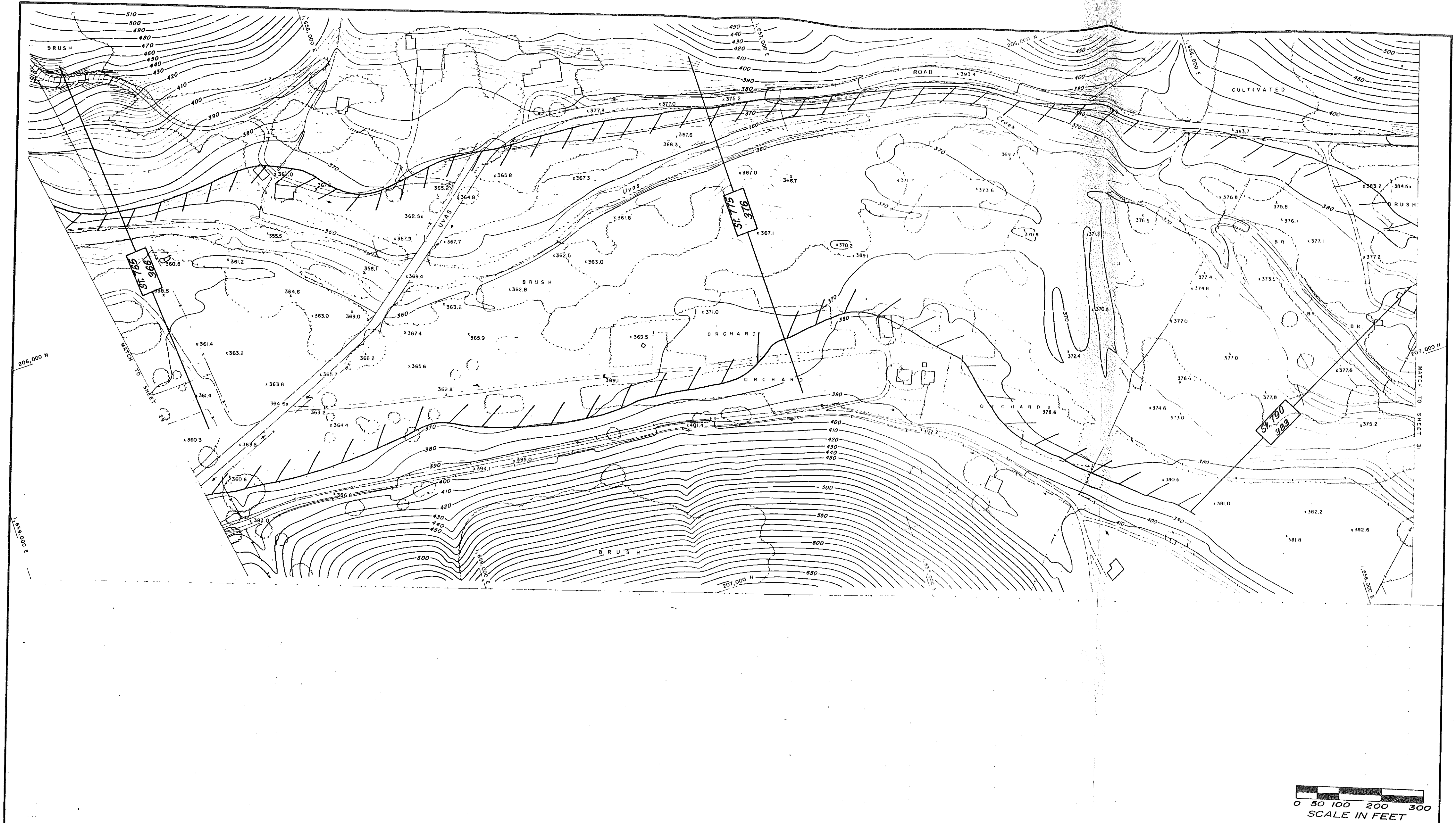

FIG. 2–19

REFER TO TRACING FOR LATEST REVISION

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DATE OF PHOTOGRAPHY: MARCH 20,1974 6" F.L.

BASE MAP PREPARED BY Towill, Inc.

FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
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APRIL 1975

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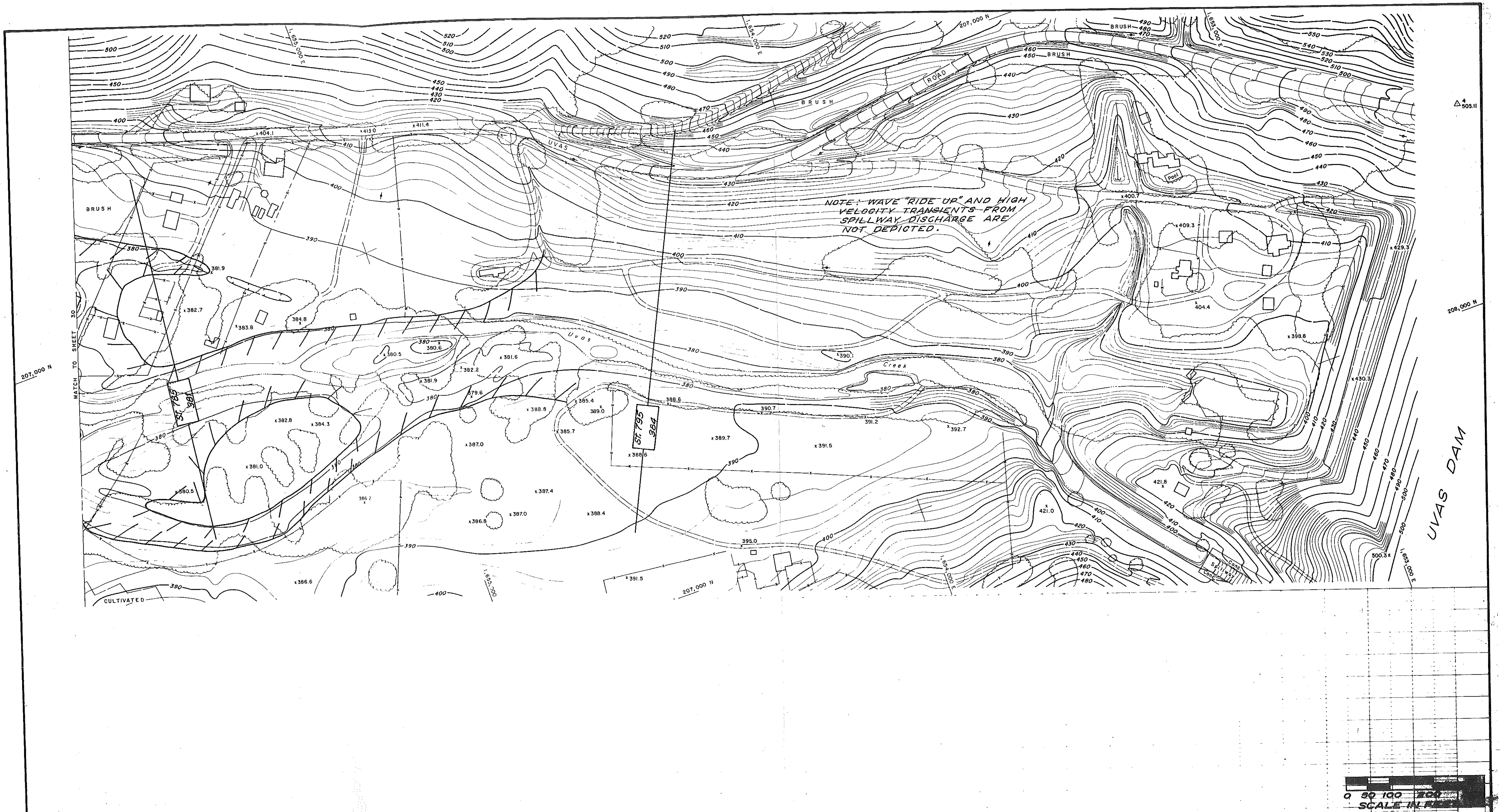
ZONE S-1 (SOUTH) PROJECT NO. 5018

UVAS - CARNADERO CREEK

SCALE

SHEET 30 OF 31



NOTE: WAVE "RIDE UP" AND HIGH VELOCITY TRANSIENTS FROM SPILLWAY DISCHARGE ARE NOT DEPICTED.

FIG. 2-20

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BASE MAP PREPARED BY Towill, Inc.

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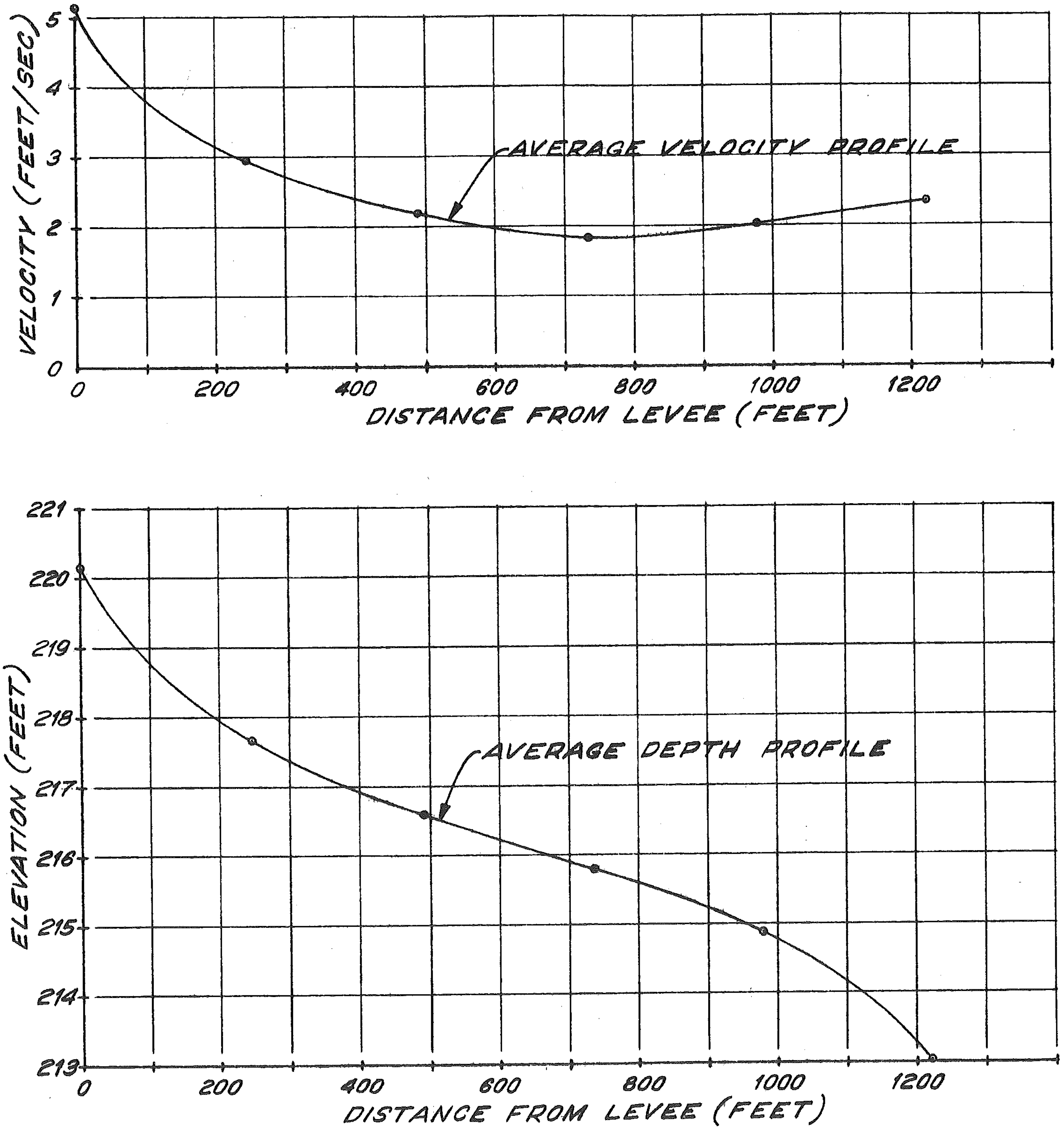
SCALE
SHEET 31

JOB NO. 4246

Geometry was developed for cross sections spaced approximately 200 feet parallel to the levee which describe the overland flow area. An HEC-2 run was utilized to establish initial conditions for base flow (see Appendix A-15) of 1,000 cfs. The HEC-2 geometry input data was then processed by the HEC GEDA program Geometric Elements from Cross Section Coordinates to develop geometry (see Appendix A-16) at calculation nodes for the HEC Gradually Varied Unsteady Flow Model. This model was operated at 1,000 cfs base flow through the breach to stabilize calculations. After stabilization, the flow was increased to 9,000 cfs over an interval of one hour, and the flood wave depths under varied flow were calculated at one second intervals. This latter condition simulated a progressive failure and breaching of the levee. The program printed results of the overland flood flow every five minutes during the simulation period for locations spaced at 25-foot intervals up to 1,250 feet from the levee. (See Appendix A-17).

The results of this analysis are shown in Figure 2-21 which presents a depth and velocity profile at one hour after levee failure (maximum discharge). A rapid expansion of flow occurs due to the relatively level overbank area. Extreme high velocities occur within 200 feet of the levee failure as the scour action continues to increase the size of the flow area. The velocity decreases to approximately 2 to 3 feet per second as the



NOTES: 1. ONE HOUR AFTER FAILURE
2. MAXIMUM DISCHARGE AT LEVEE = 9,000 C.F.S.

LEVEE FAILURE
NORTH OF MILLER AVENUE
OVERLAND FLOW VELOCITY & DEPTH PROFILES

FIG. 2-21

distance from the levee increases. However, at the maximum discharge of 9000 cfs there still is approximately 3 feet per second velocity at depths over 3 feet at a distance of 1250 feet from the levee. This would cause severe damage to any structure located in this area. Local channelization can be expected in certain areas as loose material is eroded which will cause the velocity and depth to be increased as the flow is channeled through a smaller area.

The analysis was performed under broad assumptions due to the complexity of this flow pattern. The results indicate the high probability of significant damages due to velocity in the overbank areas.

SECTION 3

ECONOMIC ANALYSIS

The San Francisco District of the Corps of Engineers has found, in a preliminary evaluation, that the proposed Hayes Valley Reservoir Project in South Santa Clara County does not provide sufficient flood control benefits to warrant Federal participation. According to its calculations, the Corps showed the annual benefits from flood control, water supply and recreation to equal no more than 94 percent of the annual costs of the project. This was based on a 45,000 A.F. reservoir and 14-foot diameter diversion pipeline from Uvas to Hayes Valley Reservoir. In subsequent calculations, after the original findings had been presented and after adding benefits associated with the Llagas Project, the Corps reduced the benefit to cost ratio from .94 to .80. This latter relationship is shown in office files and has not been released except informally. Because of its findings, including those not released officially, the Corps has not encouraged further studies of the Hayes Valley Project.

The South Santa Clara County Water Conservation District Board of Directors believe the Hayes Valley Project is the one which best serves the several needs of the people of their District. The Water District and the South Santa Clara Valley Water Conservation District are concerned that a more complete investigation be made before the Project is declared by the Corps to be ineligible for Federal flood control funding. The two districts have joined informally to underwrite a review of Corps' findings by retaining a hydrologist and an economist. This section of the report treats of the economic review and its findings.

The economist has addressed himself to three tasks. The first is a review and evaluation of the most recent study by the Corps, designated the 1975 study. The second is a review and updating of the study prepared in 1965, designated the 1965 study. The third is the preparation of a set of flood damages estimates which in the opinion of the economist more accurately quantifies the damage values and their concommitant effect on project feasibility. In each case, the economist worked with the hydrologist to convert the data into annual equivalent flood damages for direct comparison with estimates prepared by the Corps.

It is believed the review and analysis has been sufficiently detailed to secure a reasonably complete understanding of the Corps 1975 and 1965 studies. It is recognized that a period of two months is insufficient to fully appraise the flood damage potential in the Uvas-Carnadero floodplain, the effective area of the proposed Hayes Valley Project, nor to completely evaluate the beneficial effects of the Project. It is hoped the illustrative calculations based on increased acreages and revised damage figures developed by the hydrologist and economist respectively will serve to assist the Corps in its deliberations and in its decisions with respect to further study of the potential of the Hayes Valley Project.

THE 1975, HAYES VALLEY PROJECT EVALUATION

Three documents were secured from the Corps to determine the basis for the Corps' estimates of flood damages and flood damages prevented by the proposed Hayes Valley Project. These were computer runs for damages in nonagricultural acreages in Reaches IV and V, as designated in the 1975 study, and the backup data prepared for Reaches I through VI for agricultural damages. These reaches are shown in Figure 2-4. The study of agricultural damages included estimates of total acreages subject to inundation. It is assumed in this analysis that all benefits and costs presented in the 1975 study by the Corps represent late 1974 or January, 1975, prices.

Agricultural Damages Estimates

Data in this document provide complete coverage of the area subject to flooding as calculated by the Corps of Engineers. From a reading of the tables and notes, it appears that a check was made of the flood-prone area and that acreage estimates were made by use of standard techniques. However, arbitrary "study limits", Figure 2-4, were utilized on the easterly and southerly areas that would neglect severe flood damages in the Soap Lake area which can be attributed to the Uvas-Carnadero flood flows.

Acreages in the floodplain under different levels of flooding were estimated to be as follows:

Table 3-1
Acreages in the Uvas-Carnadero Floodplain
Reaches I through VI

	SPF	100-Year	50-Year	25-Year
Agricultural	6,198	6,198	4,776	2,806
Non-Agricultural	1,200	1,200	700	185
Total	7,398	7,398	5,476	2,991

Agricultural acreages were estimated to be distributed under different levels of possible flooding as follows:

Table 3-2
Acreages in the Uvas-Carnadero Floodplain

By Flood Level and Agricultural Crop

	SPF	100-Year	50-Year	25-Year
Asparagus	50	50	0	0
Garlic	200	200	200	200
Lettuce	400	400	400	400
Peppers	1,109	1,109	821	413
Sugar Beets	900	900	848	600
Tomatoes	2,919	2,919	2,201	1,000
Subtotal	5,578	5,578	4,470	2,613
Orchards	620	620	306	193
Total	6,198	6,198	4,776	2,806

Table 3-3
Agricultural Acreages By Flood Level and Reach

	SPF	100-Year	50-Year	25-Year
I	2,517	2,517	1,737	1,272
II	1,143	1,143	713	410
III	1,031	1,031	914	730
IV	1,365	1,365	1,330	394
V	115	115	82	0
VI	27	27	0	0
Total	6,198	6,198	4,776	2,806

From the foregoing summary tables, it can be seen that agricultural acreage accounts for most of that subject to flooding. The smaller the flood, and the more frequent, the greater the percentage in agriculture, ranging upward from 84 percent in SPF and 100-year floods to 94 percent for 25-year floods. Row crops predominate, with over 90 percent of all crop lands at every flood level. Reaches I, II, and III, the three reaches between Uvas-Carnadero at Highway 101 downstream to the Pajaro River at the southern end of the Corps study area, include over 70 percent of all agricultural lands in the flood-prone area for less frequent floods, and over 85 percent for the 25-year flood. Reach I, the Corps designated Soap Lake Area, includes about 40 percent of the total under all flood levels studied. This value could easily double if the "study limits" were revised to include the total Soap Lake Area.

Flood damages per acre of crop land in the Corps 1975 Report were estimated to be as follows:

Table 3-4
Average Damages Per Acre

Crops	Damages
Asparagus	$ 5.00
Garlic	100.00
Lettuce	212.00
Peppers	109.00
Sugar Beets	73.00
Tomatoes	93.00
Orchards	7.00

These dollar amounts were used in conjunction with acreage figures to obtain flood damages for the four levels of flooding. No allowance was made for different flood depths in the damage estimates. These damage values were adjusted upward by 14 percent after acres and damages were combined to place them on an equality with costs estimated for late 1974 or early 1975.

Based upon the acreages and damage values set forth above, agricultural damages associated with flooding in the Uvas-Carnadero floodplain were estimated in the Corps' study, Table 3-5.

Table 3-5
Agricultural Damages By Level of Flooding
1974-1975 Prices

Flood	Damages
Standard Project	$ 646,694
100-Year	646,694
50-Year	527,851
25-Year	328,292

Reduced to annual equivalent damages, agricultural damages were computed to be $39,000 per year without the Hayes Valley Project, and $5,000 with the Project, for a reduction or a damage prevention benefit of $34,000.

Non-Agricultural Damage Estimates

Non-agricultural acreages are found to some extent in every reach in the floodplain. Total agricultural and non-agricultural acreages are distributed in the agricultural analysis as follows:

Table 3-6
Acreages By Reaches, SPF and 100-Year

Reach	Agricultural	Non-Agricultural	Total
I	2,517	100	2,617
II	1,143	90	1,233
III	1,031	304	1,335
IV	1,365	100	1,465
V	115	500	615
VI	27	106	133
Totals	6,198	1,200	7,398

Non-agricultural damage data were secured from the Corps of Engineers for Reaches IV and V only. Data in these two tabulations were supplied at the request of the consultants. It was understood all of the non-agricultural damages were included in these two tabulations. Obviously, there are acreages classified as non-agricultural located in Reaches other than IV and V. No data was secured as to such acreages and no damage figures appear to have been computed for such acreages. Table 3-7 summarizes non-agricultural acreages in Reaches IV and V for the several flood levels as found in Corps' tabulations.

Table 3-7
Non-Agricultural Acreage, Reaches IV and V
By Flood Level in Acres
Analyzed in 1975 Corps Report

Reach	SPF	100-Year	50-Year	25-Year
IV	103	103	98	46
V	158	158	94	0
Total	261	261	192	46

The maximum of 103 acres in Reach IV, SPF, agrees with the 100 acre estimate in Table 3-6. The maximum of 158 acres in the Corps' tabulation for Reach V, SPF, falls substantially short of the 500 acres estimated to be non-agricultural - Table 3-6. Undoubtedly, the difference in Reach V and the non-agricultural acreages in Reaches I, II, III and VI are largely in streets, roads, highways and other uses than those identified in the non-agricultural detail for Reaches IV and V.

Non-agricultural lands in Reaches IV and V were classified in total as follows:

Table 3-8
Non-Agricultural Lands, Reaches IV and V

	Acres			
	SPF	100-Year	50-Year	25-Year
Residential	106	106	80	12
Commercial	46	46	38	2
Industrial	100	100	74	32
Public	9	9	0	0
Total	261	261	192	46

Damages are estimated separately in the analysis for structures and contents. For simplicity, damages in thousands of dollars are shown in Table 3-9 for the combined effect for the four categories and for the four levels. It is understood all damage figures represent estimates based upon areas, structures, contents, flood depths and other typical considerations.

Table 3-9
Non-Agricultural Flood Damages
Reaches IV and V, January, 1975
Thousands of Dollars

	SPF	100-Year	50-Year	25-Year
Residential	$ 418	$ 46	$ 16	$ 1
Commercial	320	38	10	2
Industrial	563	254	238	82
Public	328	22	0	0
Total	$1,629	$ 360	$ 264	$ 85
Rounded	$1,630	$ 360	$ 265	$ 85

Damages per acre were calculated as follows from the acres and damages cited.

Table 3-10
Average Flood Damages
Reaches IV and V
January, 1975, Dollars/Acre

	SPF	100-Year	50-Year	25-Year
Residential	$ 3,943	$ 434	$ 200	$ 83
Commercial	6,957	826	263	1,000
Industrial	5,630	2,540	3,216	2,563
Public	36,444	2,444	0	0
Total	$ 6,245	$1,379	$1,380	$1,848

Average damages per acre decline substantially between the Standard Project Flood and the 100-year flood, reflecting the reduced depth of water. All other factors remain unchanged. Between the 100-year flood and the 50-year flood and between the 50-year and 25-year, damages per acre decline in most cases. That there is some irregularity in rate of decline or in the change in damages per acre, including some rising as well as some falling, is not unusual, inasmuch as data are based upon an irregular assortment of circumstances in the floodplain.

Flood Damages and Reduction In Flood Damages Associated with Hayes Valley Project

Agricultural and non-agricultural flood damage data from the two sources were introducted into a computer model by the hydrologist to verify the reasonable accuracy of the interpretation of the meaning and relative completeness of the information secured from the Corps. The comparative results are shown in Table 3-11.

Table 3-11
Average Annual Damages
A Comparison of Corps and Consultant Estimates
1975 Study

	Without Project	With Project	Damage Reduction
1975 Corps' Values	$ 66,000	$ 8,000	$ 58,000
HEC-5C, 1975 Data	55,000	12,000	43,000

Without project damages were lower in the conultant's HEC-5C computer run. This is attributable to damages omitted in the

HEC-5C run but included in the Corps' compilation, while the greater precision of integration techniques in the new HEC-5C analysis also reduce average annual damages somewhat.

Remaining damages, in contrast to "without project" damages, were higher in the HEC-5C run than in the Corps' estimates, in actual dollars and in relative amount. This is attributed to a lesser claim for flood control effects in the HEC-5C analysis.

Benefits of the proposed project appear to be less than the Corps had calculated, due both to a lesser average annual damage and to a reduced claim of effectiveness of the project. In general, the similarity of the two sets indicates the review was reasonably representative of the Corps' procedures and findings with respect to the Hayes Valley Project's benefical effect.

THE 1965 REPORT ON THE UPPER PAJARO RIVER

In 1965, the Corps reported on an investigation of flooding on the Upper Pajaro River. In that investigation, Reaches designated IV and V were similar to Reaches I through VI in the 1975 study. While recognizing a slight difference in acreage, it is believed the two studies can be compared without undue distortion.

The major difference between the 1965 and 1975 studies is that the 1965 study was based primarily upon recorded floods and flood damage figures compiled by the Corps at the time of the floods. By contrast, the 1975 study was based entirely upon computed flood areas and estimates of potential damages under different levels of flooding without validation by historical damage data. Both approaches are valid and where there is a lack of recorded flood damages, the latter method is the only one available for estimating project benefits.

Historical flood data may be unrepresentative in that they were compiled when conditions in the flood area were different from now. After all, planned protection can only relate to present and future conditions. Adjusting data compiled at different times in the past to a single study date can be filled with over or under estimation. Also, compilation of flood damage data is more of an art than a science. In practice, the isolation of flood damage from rain or wind damage or from other circumstances can only be approximate. Obviously, if the damage is not flood related or is flood related but not subject to control by the specific project, the data compiled may be more or less pertinent. Also, damage data may be wide of the mark depending upon when it was compiled and whether or not those supplying the information knew the full extent of the damages suffered when interviewed and whether or not those interviewed were representative.

On the other hand, estimation of possible future damages in hypothetical floodplains is also fraught with possible error. All such calculations rely on factors derived from historical floods and statistical generalizations made on the basis of the kind of historical flood damage reporting known to be less than perfect. Therefore, neither approach is infallible or to be used exclusively. Certainly, the data compiled in 1965 are useful as reference for present day calculations and are in line with current guidelines for evaluation of flood damages (Federal Register, August 15, 1974).

The two reaches in the Uvas-Carnadero floodplain are described in the Corps' 1965 report, Appendix D., Basin Economy and Project Benefits, Flood Control and Allied Purposes, Pajaro River Basin, California, 1965.

Reach IV	Near confluence of Bodfish and Uvas Creeks to Bloomfield Avenue and west of Llagas Creek.
Reach V	From Bloomfield Avenue to the Pajaro River and west of Llagas Creek.

Floods for 1955, 1958 and 1963 were included in the study. In these three floods, complete coverage was obtained in field evaluations of non-agricultural damages while agricultural damages were determined by sample coverage. From the explanation of procedures (P. D-7), it appears those who compiled the data were aware of the problems associated with data gathering.

Acres subject to flooding in 1955, 1958 and 1963 in Reaches IV and V are shown below. In addition, the acreage estimated to be flooding under S.P.F. conditions is presented.

Table 3-12
Areas Subject to Flooding
1955, 1958, and 1963 (Actual), S.P.F. (Estimated), Acres

Reaches	1955	1958	1963	SPF
IV	3,150	2,330	1,100	5,090
V	2,450	2,360	1,715	3,435
Total	5,600	4,690	2,815	8,525

Source: Page D-8, Appendix 1965 Study.

Damages in the two reaches combined, were adjusted in the 1965 study from the level which prevailed at the time of the flood to February, 1964. The adjustment, according to Corps custom, included adjustments to reflect changes. On Page D-12, it is stated price indices of several kinds were used to raise values to a common February, 1964, level. The effects of the composite adjustments were very nominal, being less in every instance than inflation alone. Assuming the adjustments to February, 1964 are appropriate, it would be necessary to make additional adjustments to compare historical damages with current damage and cost figures.

Damages in February, 1964, prices were as follows for the three floods and for the S.P.F. as visualized by the Corps at that time.

Table 3-13
Flood Damages In Reaches IV and V
February, 1964, Thousand Dollars

	1955	1958	1963	S.P.F.
Residential	$ 18	$ 8	$ -	$ 26
Commercial	15	7	-	21
Agricultural	975	505	207	1,324
Emergency Aid	10	5	2	14
Roads	67	24	19	77
Public Utilities	-	-	15	-
Bank Erosion	-	-	-	-
Total	$1,095	$549	$243	$1,462

Source: Pages D-11 and D-12, Appendix D, 1965 Study.

Damages presented in the 1965 (February, 1964 prices) study were mainly agricultural in nature. Relatively little damages is shown for residential or commercial categories. From interviews in Gilroy and neighboring areas, accounts of the flood in 1955, and viewing flood pictures taken in 1955, it appears damages may have been understated, both in the nominal amounts shown in the non-agricultural areas and in the more substantial damages shown for agricultural areas.

Average annual damages in Reaches IV and V totalled $145,000 in February, 1964, prices according to the 1965 Report. These damages were adjusted by the Corps for future growth in the floodplain. The average annual damages were increased on a fifty-year base to $250,000 and on a 100-year base to $380,000.

Although several serious questions can be raised as to the adequacy of the flood damage data compiled following the 1955, 1958 and 1963 floods, it does not appear that overstatement is one of them. In particular, there is only a minimal sum for damages to residences, commerce and industry, and no losses are included for known interruptions of traffic on Highway 101 and on Southern Pacific Railroad lines. Thus, utilization of the 1964 data updated for inflation and nominal real growth to 1975 as a comparison with 1975 Corps data does not represent a distortion in terms of overstatement of possible damages. Rather, it could seriously understate potential damages since there have been substantial changes in the area in the past ten to twenty years. Large increases in residential, commercial and industrial developments coupled with a continuing shift from orchards to highly vulnerable row crops has occurred in the most flood-prone areas. A concrete example of distortions which may occur due to different adjustments of historical data is cited later in this report.

Flood damage data for February, 1964, have been adjusted upward to reflect 1975 (January) prices and conditions. It is believed the adjustment for inflation based upon the San Francisco-Oakland Cost of Living Index reflects inflationary effects adequately. A further adjustment of 10 percent to reflect real changes in agricultural values, such as changing cultural practices which increase vulnerability to flood damage, is considered minimal. And, further, a 20 percent adjustment for non-agricultural damages, to reflect changes in land use between 1964 and 1974-75, is suggested because real growth has been above the national average and because the damage base in 1964 in non-agricultural categories was so low.

Between 1964 and 1975 (December 1963 and December 1974) the San Francisco-Oakland Cost of Living Index rose from 92.4 to 152.1 or by 64.6 percent. February, 1964, damage estimate values in the 1965 report are raised by 65 percent to reflect this change. As indicated above, real change in the agricultural sector is estimated at 1 percent per year, or in round numbers, 10 percent in 10 years. Real change in the non-agricultural sector is estimated at 2 percent per year or 20 percent in 10 years. Table 3-14 shows the damages as set forth in 1965 and as conservatively escalated to 1975 values.

Table 3-14
Historic Flood Damages in Reaches IV and V
1965 Study Adjusted to January, 1975
Damages in Thousands Dollars

	February, 1964	January, 1975	Ratio 1975 to 1964
S.P.F.	$ 1,192*	$ 2,170	1.82 to 1.00
1955	1,085	1,988	1.83 to 1.00
1958	549	1,003	1.83 to 1.00
1963	243	443	1.82 to 1.00

* Estimated damage of $1.46 million reduced to conform to 1975 Report's acreage.

Before subjecting the adjusted figures to analysis, it is significant to note the substantial effect of different adjustment factors upon historical flood damage data by using a recent Corps study in the Watsonville area for comparision.

Damage Adjustments, Watsonville and Gilroy

Watsonville, downstream on the Pajaro from Gilroy, and Gilroy are similar in many respects including the existence of floodplain areas. Floodplain areas in the Watsonville area are shown in Figure 3-1. Both communities have grown substantially in area, assessed valuation, building permits and in sales subject to taxes over the past 20 years. It is reasonable to assume that historical flood damage potentials in both communities would have corresponding increases.

Damages incurred in the Lower Pajaro Valley at Watsonville in the 1955 flood were adjusted by the Corps from $679,000 to $2,100,000 to reflect prices and conditions as of June, 1974. This information was published in the Corps' information pamphlet "Flood Control Alternatives for Pajaro Valley". If the $2,100,000 were raised another 6% to reflect inflation and other changes between June 1974 and January 1975, it would become about $2,226,000. This is 3.28 times the reported $679,000 of damages in 1955. The increase appears reasonable, given the change in prices and conditions in the area.

Using the same 3.28 factor, the $954,000 of damage experienced in the 1955 Uvas-Carnadero Floodplain would be equivalent to some $3,129,000 in January 1975 prices and conditions. This is substantially more than the $1,988,000 estimated in Table 3-14 and thus underscores the conservative nature of the escalation of the 1964 values. By a similar set of calculations, the 1958 Uvas-Carnadero figures become $1,250,000 in January 1975. Interestingly enough, the 1963 damage figures when adjusted by either method, yield similar results. The following summarizes the difference between adjusted figures taking 1964 as the base and using the Corps' adjustments to June 1974 and the adjustment factor set forth in Table 3-14.

Comparison of Adjustment Factors Uvas-Carnadero Historic Flood Damages January, 1975

Year	Cost of Living, etc.	Corps Pajaro Method	Corps/COL
1955	1,988,000	3,129,000	1.57
1958	1,003,000	1,250,000	1.25
1963	443,000	450,000	1.02

It appears that the adjustments between 1963 and 1975 are in line, but that the adjustments between 1955 and 1975, and 1958 and 1975 differ significantly. Further study of the project should include a review of adjustments to values in the Uvas-Carnadero Floodplain between the actual floods and current conditions to relate damage estimates to actual floods.

COMPARISON OF 1975 AND 1965 ADJUSTED FIGURES

From the foregoing discussion and explanation, three sets of flood damage estimates for the Uvas-Carnadero Floodplain have been secured. Although no one of them is fully acceptable, for one reason or another, a comparison among them will reveal significant differences. These differences can be seen in Figure 1-2 on which flood flows and flood damages are paired. The 1975 Corps' values, Curve I, are smaller, except for the SPF, than even the 1964 values of the earlier study, and the curve is one which rises continuously and at an accelerated rate to and including the SPF. The curve also reflects a drastic decline in flood damges between the SPF and the 100-year flood as estimated by the Corps.

CONDUCTED BY THE CORPS OF ENGINEERS AND ON INFORMATION PRESENTED ON U. S. GEOLOGICAL SURVEY FLOOD-PRONE AREA MAPS. THE FLOOD-PRONE AREAS WERE ESTABLISHED FROM LIMITED DATA AND MAY NOT BE SUITABLE FOR FLOOD INSURANCE STUDIES.

2. CORRALITOS CREEK FLOOD PLAINS ARE BEING DEVELOPED CURRENTLY BY THE CORPS OF ENGINEERS SAN FRANCISCO DISTRICT, AND WILL BE PRESENTED IN A FLOOD PLAIN INFORMATION REPORT.

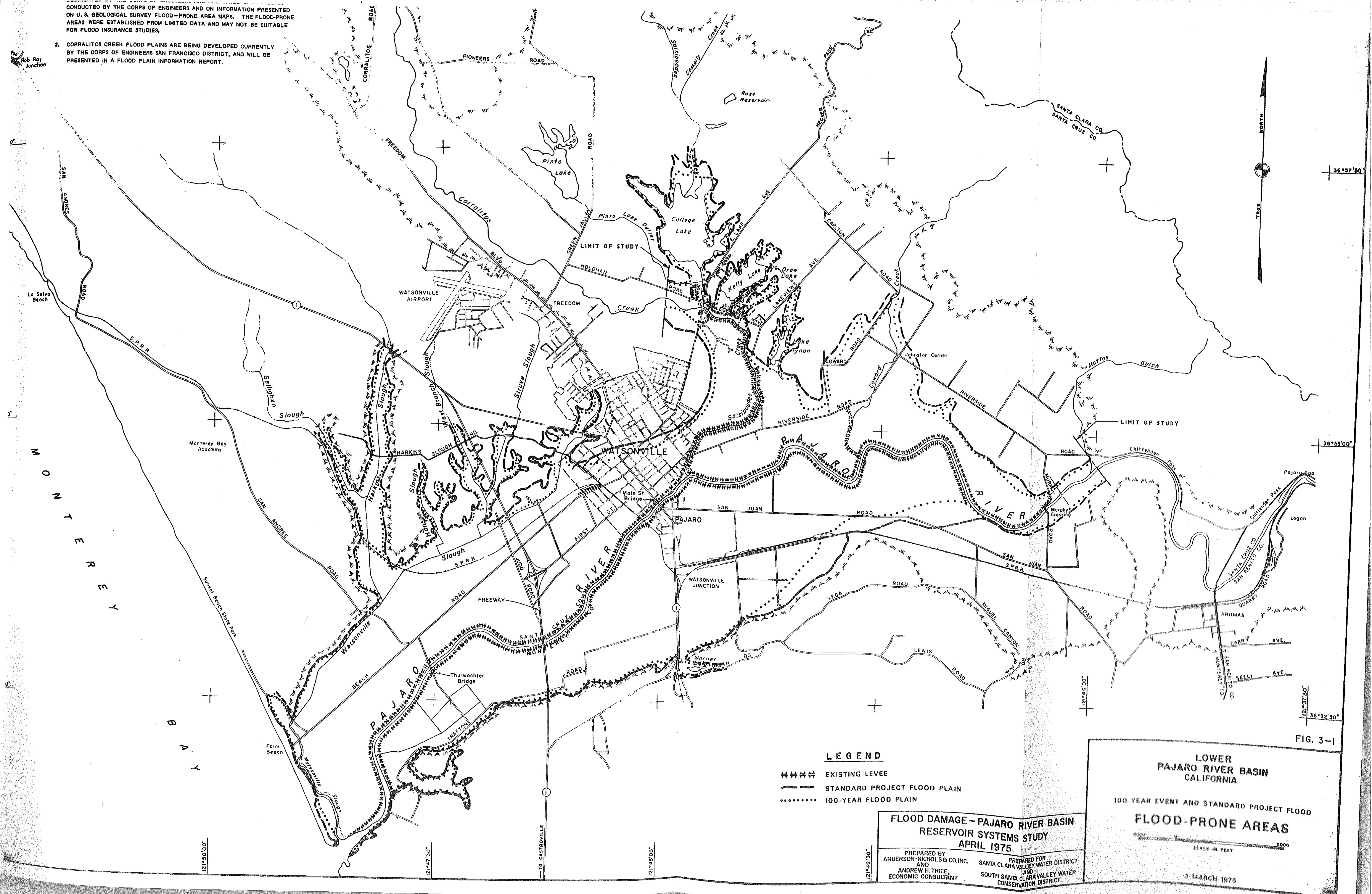


FIG. 3-1

LEGEND

╫╫╫╫ EXISTING LEVEE
— — STANDARD PROJECT FLOOD PLAIN
········ 100-YEAR FLOOD PLAIN

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO.INC.
AND
ANDREW H. TRICE,
ECONOMIC CONSULTANT

PREPARED FOR
SANTA CLARA VALLEY WATER DISTRICT
AND
SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT

LOWER
PAJARO RIVER BASIN
CALIFORNIA

100-YEAR EVENT AND STANDARD PROJECT FLOOD

FLOOD-PRONE AREAS

2000 0 6000
SCALE IN FEET

3 MARCH 1976

More important than the form of the curves is the fact that the historic flood damages (Curve II), with only basic escalation (82%), actually exceed the 1975 damage estimates (Curve I). Furthermore, with such low damages shown for nonagricultural development in 1965, a factor emphasized by the current estimates of potential damage in nonagricultural land use areas, it would appear that even the adjusted 1965 data does not fully reflect damages as experienced nor as may potentially occur today.

When 1964 adjusted values are converted by the HEC-5C program into average annual figures, damages without project are $191,000, residual damages are $87,000 yielding a flood damage reduction of $104,000. The damages and reductions under each one of the flood damage curves is summarized in Table 3-15.

Table 3-15
Average Annual Damages

Curve		Without Project	With Project	Damage Reduction
I	1975 Corps	$ 66,000	$ 8,000	$ 58,000
II	1975 HEC-5C	55,000	12,000	43,000
III	1964, Adjusted	191,000	87,000	104,000

REVISED HYDROLOGY AND ECONOMICS FLOOD DAMAGE CALCULATIONS

Although it is not possible in the extremely short time available to make a complete analysis of flood damages in the Uvas-Carnadero Floodplain, an illustrative set of calculations has been prepared. This is presented to demonstrate some of the techniques which might be utilized in a more complete analysis. This is in no way a substitute for the kind of detailed study recommended to the Corps for the ensuing fiscal year.

Revised Acreage

The hydrologic analysis indicates that additional acreage would be subjected to flooding in the 100-year and Standard Project Floods. To reflect this change, the 100-year and SPF flood area has been increased and the 100-, 50- and 25-year flood areas have been redesignated as the 50-, 25- and 12-year flood areas, respectively.

In addition to changes in the six reaches studied by the Corps in 1975, another reach has been added. This reach extends from Santa Teresa Expressway to below the Uvas Dam. It is designated Reach VII. The following table presents the revised acreage figures for the seven reaches and the five flood levels.

Table 3-16
Revised and Expanded Floodplain Areas, Acres

	Flood Recurrence Interval				
	SPF	100	50	25	12
Agricultural	6,909	6,843	6,326	4,831	2,806
Non-Agricultural	576	432	261	195	46
Other	1,722	1,659	1,199	660	260
	9,207	8,934	7,796	5,686	3,112

Revised Damages

Agricultural damage values in the 1975 Study the Corps do not reflect the depth nor velocity effects of different intensities. Nor do the damage figures recognize the differences in depth of flooding due to locational considerations. By use of row crop budgets prepared for San Benito County farmers in 1973, budgets for orchards coupled with data collected from local growers, estimates have been made of possible damages to the crop lands including that added due to hydrologic changes noted herein.

Three areas are recognized to conform to flood flow control points. Reach VII uses Hecker Pass Bridge over the Uvas. Reaches IV, V and VI use the Highway 101 crossing of the Uvas-Carnadero and Reaches I, II and III are based on the confluence of the Uvas-Carnadero with the Pajaro.

In the estimates, consideration was given to the probability floods would occur before or after January 31. A probability of 0.67 for a flood prior to this date was assigned. This was on the basis of earlier studies made by the Soil Conservation Service for the area. Consideration was given to cultural practices and to commitments of resources in land preparation, preplant fertilizer and herbicides and to planting. Losses were related to different water depths to conform to estimates by the hydrologist for each flood flow for the area. Loss of output due to timing and depth of flooding was considered and departures of actual income from normal or average income taken as a loss to be added to costs of restoring inputs lost at the time of flooding. With lost production, an allowance was made for harvest costs not incurred.

Reach I was considered as a special case because so much of the land lies 10 feet or more below flood level. Damages estimated for Reach II and Reach III were increased 70 percent to allow for substantial loss of equipment, farm structures, stored supplies and the like. In the 1955 flood, equipment rehabilitation on the Taix Ranch alone cost $240,000 (1955 dollars). This was $240 per acre at that time. Today the figure would be $500 per acre, or more.

Damages to orchards took into account flood levels and duration and their effects on the farm enterprise. Debris removal, siltation, and other direct physical effects were considered with variations to reflect depths and timing. Possible adverse effects of delays in pruning and other cultural practices were visualized, as were the possible loss of productivity due to excessive moisture at critical periods in the annual cycle. Finally, consideration was given to the share of orchard decline which might be associated with flooding. Such decline includes gradual loss of productivity, premature replanting and the waiting period while the new trees are reaching full production again.

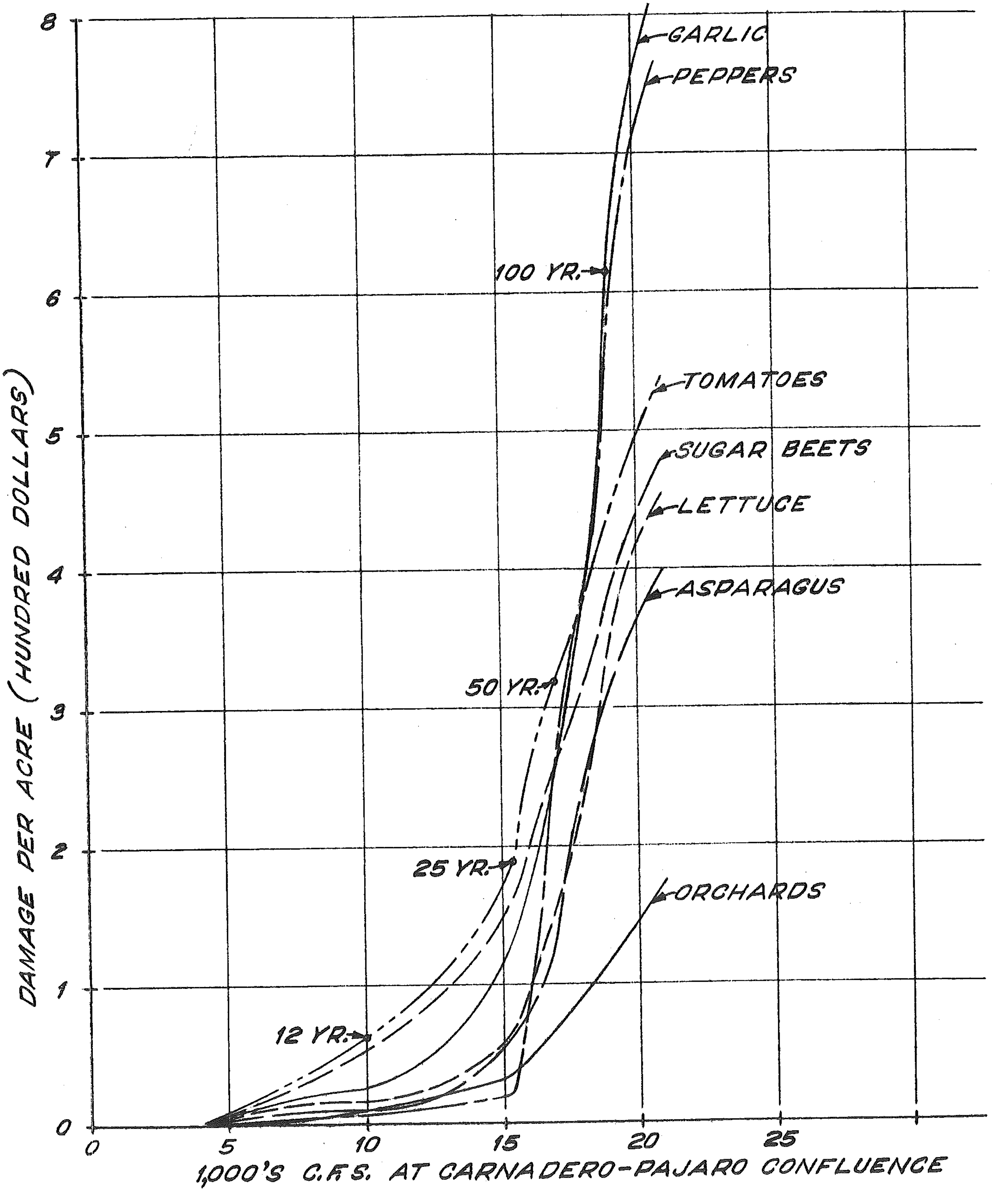
Table 3-17 summarizes basic damages by crops and flood level. These damages were used with acreages in Reaches II and III.

Table 3-17
Flood Damages by Crops
For SPF, 100-Year, 50-Year, 25-Year and 12-Year
Dollars Per Acre in Reaches II and III

	SPF	100-Year	50-Year	25-Year	12-Year
Asparagus	415	310	130	70	12
Garlic	830	615	255	140	25
Lettuce	455	335	165	70	15
Peppers	770	575	265	20	10
Sugar Beets	480	375	260	165	55
Tomatoes	540	435	320	190	65
Orchards	175	120	75	35	10

Source: Estimated by economic consultant.

Data in Table 3-17 have been plotted to show the nature of damages with different levels of flooding. Figure 3-2 presents curves for typical crops in the study area. As can be seen, damage curves for the crops differ as to height of the ordinate, but assume an S Curve form. That is, damages increase slowly as flood levels rise slowly from no flooding; rapidly as floods of medium frequency are experienced and level off when major floods



DAMAGE CURVES FOR SELECTED CROPS
REACHES II & III
UVAS-CARNADERO FLOOD PLAIN, 1975

FIG. 3-2

are encountered, with almost complete loss occurring above a given level.

Flood Damages to Residential Areas

A pattern of residential damages has been developed to reflect Corps' findings in 1975 while conforming to known flood damage relationships. That is to say, the damage differences between Reach IV and V are retained, but a smooth curve is drawn to match that developed by Stanford Research Institute [1] (SRI). Other curves have been developed to reflect water damage with different flood levels, but the SRI curves are typical and more readily adapted to present use.

According to SRI residential damage curves, no damage occurs until the first floor of the house is reached. At that point $40 of damages per $1,000 of structural value can be expected. The $40 includes an allowance for damage to contents as well as structures. At 6-inches above floor level, the damage rises to $80 per $1,000 and on up to a maximum of $285 per $1,000 at 3.0 feet or more. Based upon $100,000 per acre of residential value, damages would rise from $4,000 to $28,500 per acre under different levels of flooding in the SRI format.

---

1) A Study of Procedure in Estimating Flood Damage to Residential, Commercial and Industrial Properties in California, SRI January 1960

Some allowance should be made in residential areas for damages to lawns, shrubs, foundations and sides of houses below floor level. Flood waters which flow through air vents into subfloor areas can cause serious problems. For this reason, damage values have been extrapolated down to ground level flooding at $10 per $1,000 and $20 per $1,000 at zero (in the house) and 0.5 foot of flooding. It was also assumed homes in the area are one foot above street crown. Thus, the SRI curve of damage could be adapted to the current study by relating average flood water depths to flood frequencies to obtain a smooth curve of damage tied to flood flows.

The translation of damages per $1,000 into flood frequency levels results in the following table of values:

Flood Frequency	Average Depth, ft.	Dollar Damage Per $1,000 Structure
12-Year	.50	$ 15
25-Year	.75	30
50-Year	1.00	60
100-Year	1.25	105
S.P.F.	1.50	145

If an average value of $100,000 per residential acre is used, it can be seen that a 12-year flood would cause about $1,500 per acre of damage. A SPF would cause $14,500 of damage per acre.

Corps' estimates of residential damage in the 1975 study show an average of $5,000 per acre in Reach V under SPF conditions. This compares with $14,500 using the curve developed by use of the SRI progression modified to include damages at floor level. This disparity in damage estimates could be due to home values in Gilroy being below average, floor heights greater than one foot average, or water depths associated with given floods in residential areas are less than estimated. It is likely each element may contribute to the disparity. As an approximate adjustment, it is assumed the $5,100 per acre damage is representative of the 100-year flood rather than the SPF. This raises the average damage per acre under SPF conditions to a value in excess of $6,000, Table 3-18.

Table 3-18
Damages Per Residential Area
By Flood Flow Frequency

	SPF	100-Year	50-Year	25-Year	12-Year
Reaches II & VI	$ 6,200	$ 5,100	$ 2,600	$ 1,800	$ 600
Reach IV	350	300	200	175	150
Reach VII*	1,000	1,000	1,000	-	-

Estimated from SRI data "smoothed" by economic consultant.

* Large acreage per house. Damages potentially greater because of location and flood flow velocity.

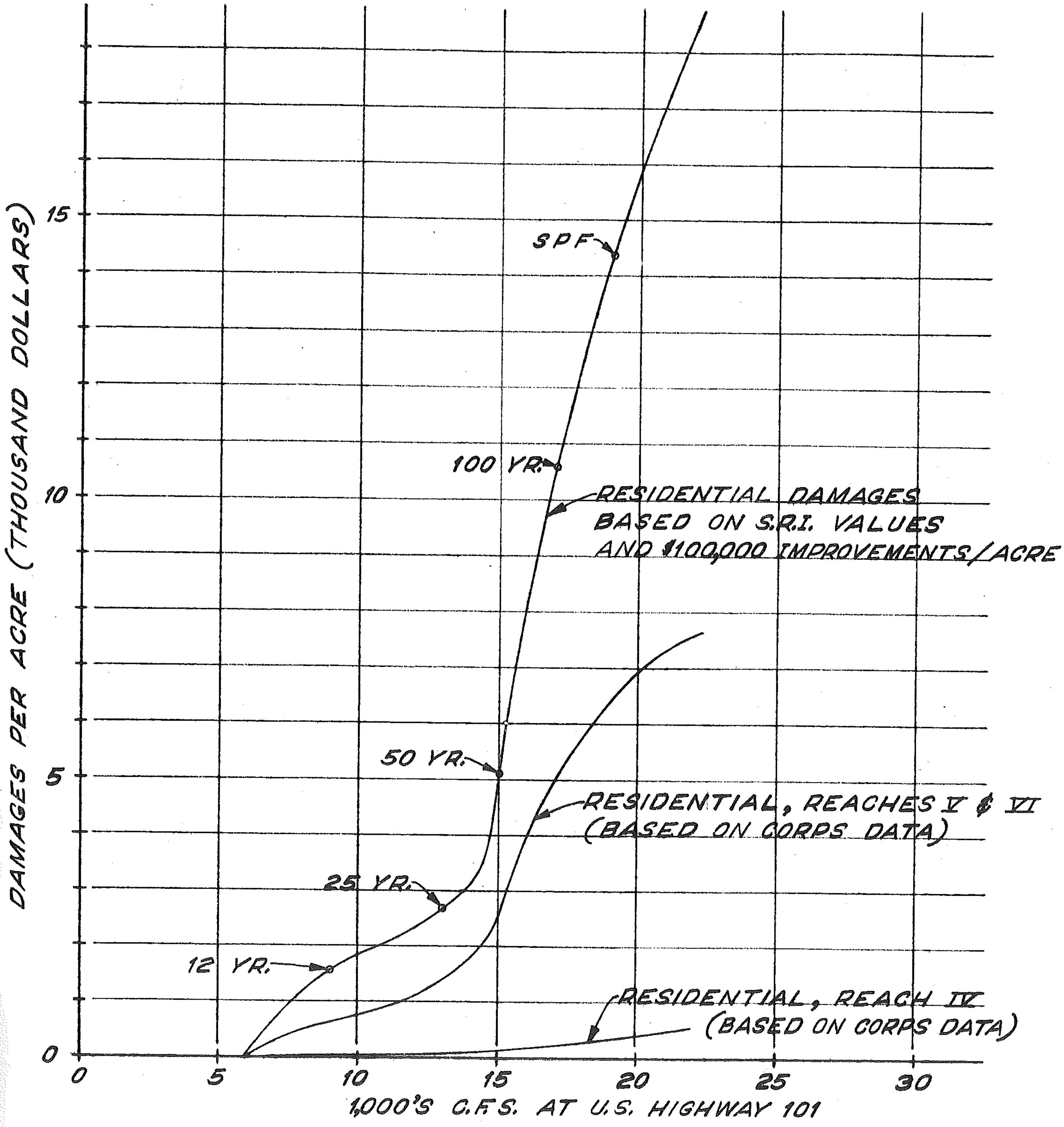
This is well below the $14,500 typical in many areas, but substantially above the $5,100 figure for damages to structures and contents in the Corps study. Damages at other levels of flooding are estimated by constructing a smooth curve similar to that based upon SRI values but lower by the relationship of $6,000 to $14,500.

Figure 3-3 illustrates the relationship between the SRI model curve and the curves for Reaches IV and V. A separate curve is drawn for the two reaches to reflect the much lower damage level computed by the Corps in 1975. The curve for Reach V is used for Reaches V and VI, residential development being considered similar in the two areas.

Commercial, industrial and public damage estimates were studied in the same way and adjusted to conform to an SRI curve of damage, Figures 3-4 and 3-5.

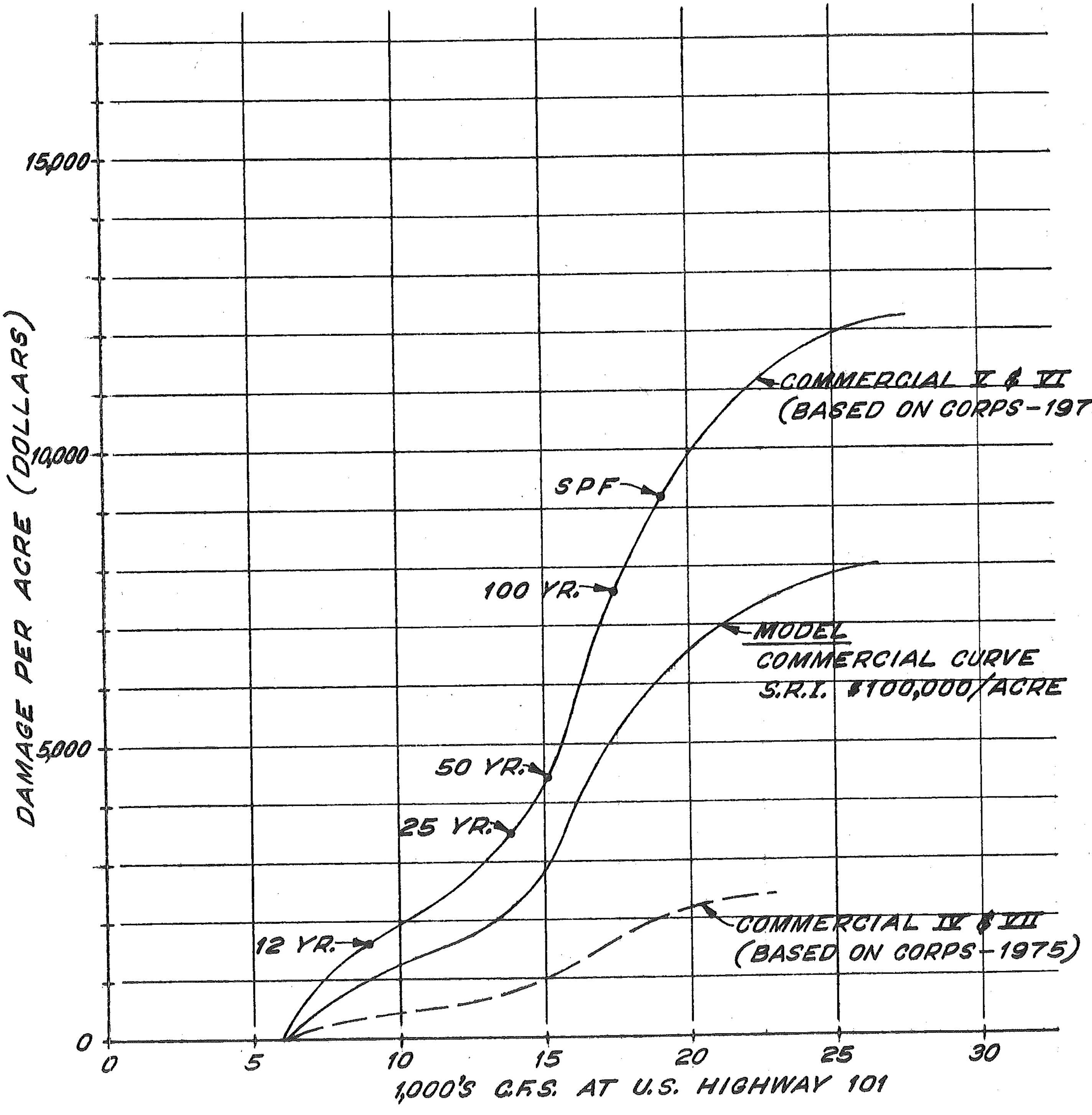
A table of values was derived from the curves for use in conjunction with acreage estimates prepared by the Corps and amplified in this study. These values are set forth in Table 3-19.

A nominal set of damage values have been assigned highways, streets, and other lands not included in any other category and are included in Table 3-19.



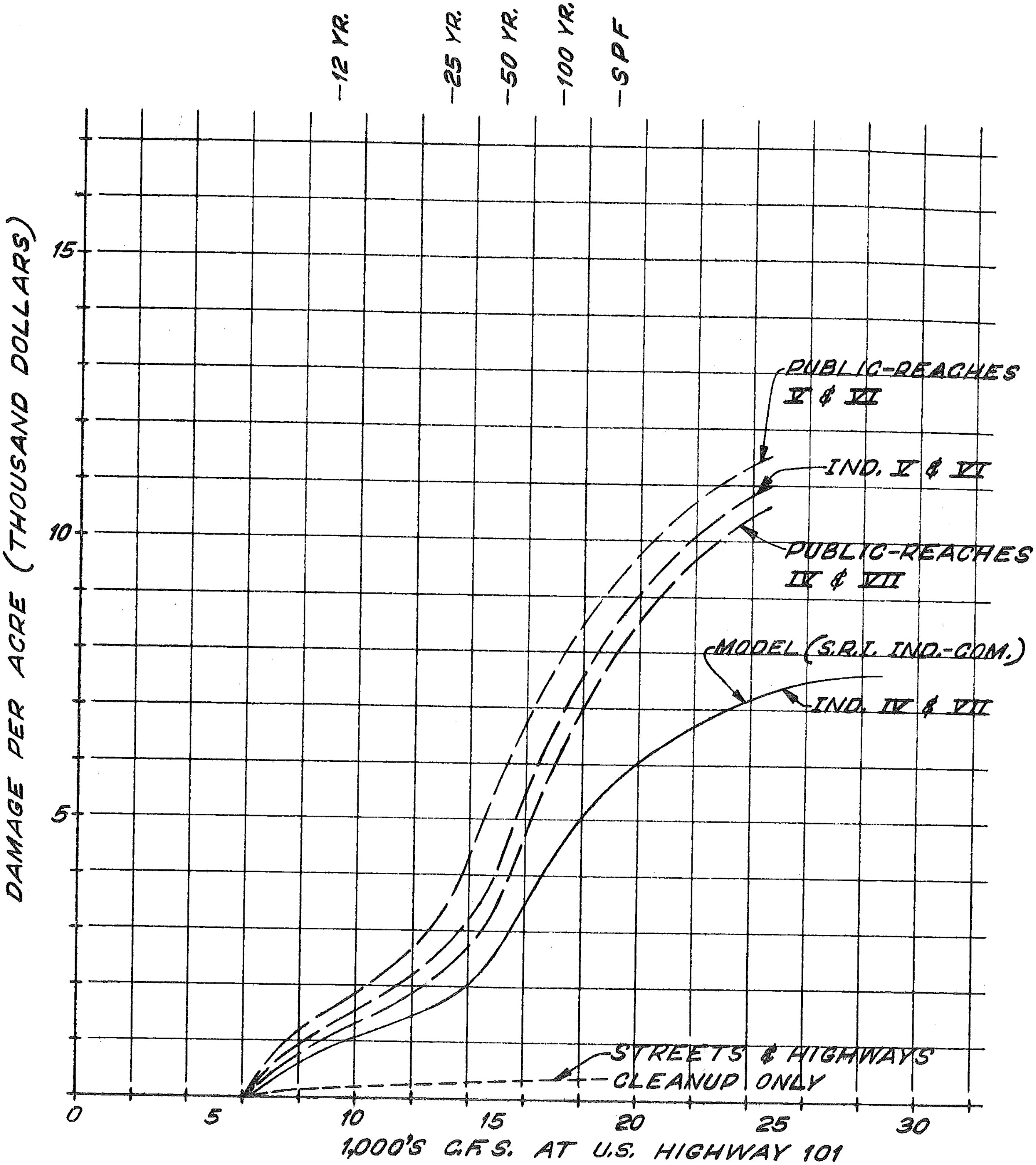
DAMAGES TO RESIDENTIAL AREAS BY REACHES

FIG. 3-3



DAMAGES TO COMMERCIAL AREAS BY REACHES

FIG. 3-4



NOTES: 1. MODEL DAMAGE CURVE BASED ON S.R.I. DATA

DAMAGES TO PUBLIC & INDUSTRIAL AREAS BY REACHES

FIG. 3-5

Table 3-19
Damage Estimate
Commercial, Industrial and Public
Streets and Other Areas, Dollars/Acre

	Flood Frequency				
	SPF	100-Yr.	50-Yr.	25-Yr.	12-Yr.
Commercial					
Reaches V and VI	$ 9,200	$ 7,600	$ 4,400	$ 3,500	$ 1,600
Reaches IV and VII	1,900	1,600	950	800	400
Industrial					
Reaches V and VI	8,400	6,550	4,200	3,200	1,350
Reaches IV and VII	5,600	4,300	2,800	2,000	950
Public					
Reaches V and VI	9,250	7,800	6,450	4,350	1,600
Reaches IV and VII	7,850	5,950	3,600	2,750	1,100
Streets and Others					
All Reaches	400	375	350	300	200

Source: Estimated by Economic Consultant.

Before considering the revised flood damage estimates and their effects on the proposed Hayes Valley Project, two basic aspects of the Uvas-Carnadero Floodplain should be made clear.

In the first place, the agricultural area subject to flooding are highly productive. Figures 3-6 and 3-7 taken in April, 1975, show intensive planting over the entire area from Gilroy to Soap Lake. Because of its suitability for the production of row crops, it is likely to remain in such use for many years to come. Within the County of Santa Clara, row crop production has stabilized at 14,000 to 15,000 acres with some 6,000 in the subject floodplain. Crop values have risen faster than inflation in recent years, experiencing a rapid rise since 1970 from less than $900 to over $1800 per acre by 1974 in gross income. After allowing for inflation, this represents a real increase of over 60% in four years.

Secondly, from the standpoint of non-agricultural development, Gilroy has grown in area and in value at a very rapid rate during the last ten years or more. Over $50 million in building permits were issued between 1964 and 1974. Adjusted to reflect 1974 prices, this $50,000,000 is equal to approximately $70 million. It is estimated that 20 to 25 percent of this building activity was south of town and in the area subject to inundation when the Uvas-Carnadero overbanks. In less than 15 months, a $10 million high school will be completed in the area between 10th street and Thomas Road and an estimated 200 to 300 homes will also be completed in the area between Thomas Road and Miller Avenue. With an average value of $30,000 per structure, these homes will increase the value of houses and furnishings within the floodplain by 10 million dollars in two years. Thus, the value of the non-agricultural land vulnerable to flooding will increase well above the current level within the near future, adding to the urgency of the proposed flood control project.

Revised Flood Damage Estimates

Based upon changes in acres and changes in damages per acre and on the shift of flood frequency to include the 12 year frequency, the economist has developed a new set of damage estimates for the Uvas-Carnadero floodplain. As indicated at the outset and as is clear from the detailed explanation, the revised estimates are illustrative only. It is believed, however, a more detailed study would give values not unlike those contained in the revisions.

Data are presented here in the same form as they were presented to the hydrologist for use in the HEC-5C runs. Reaches I, II and III are combined, IV, V and VI are combined and VII is treated separately. These geographical distinctions conform to points on the Uvas-Carnadero Creek used by the hydrologist.

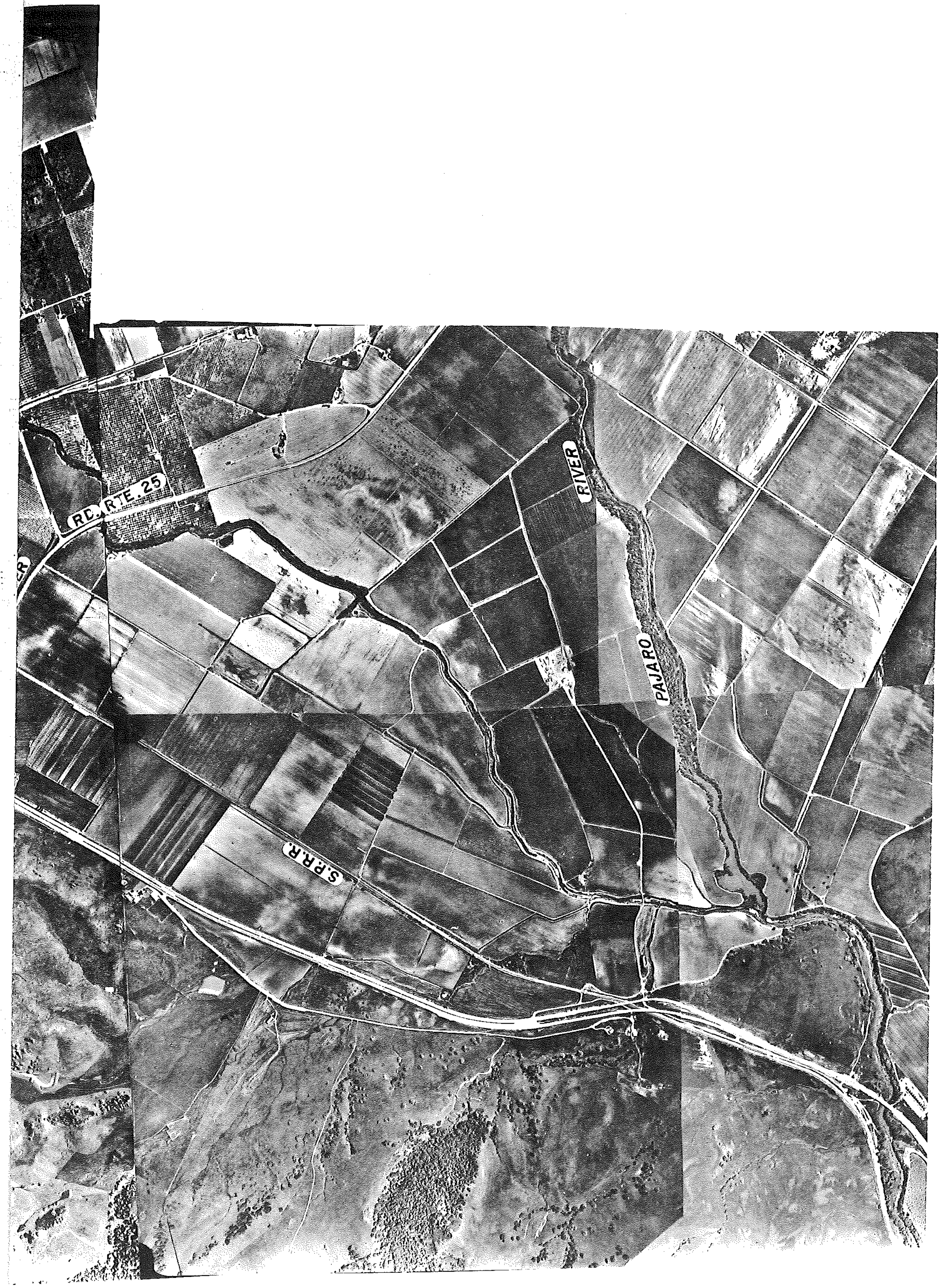
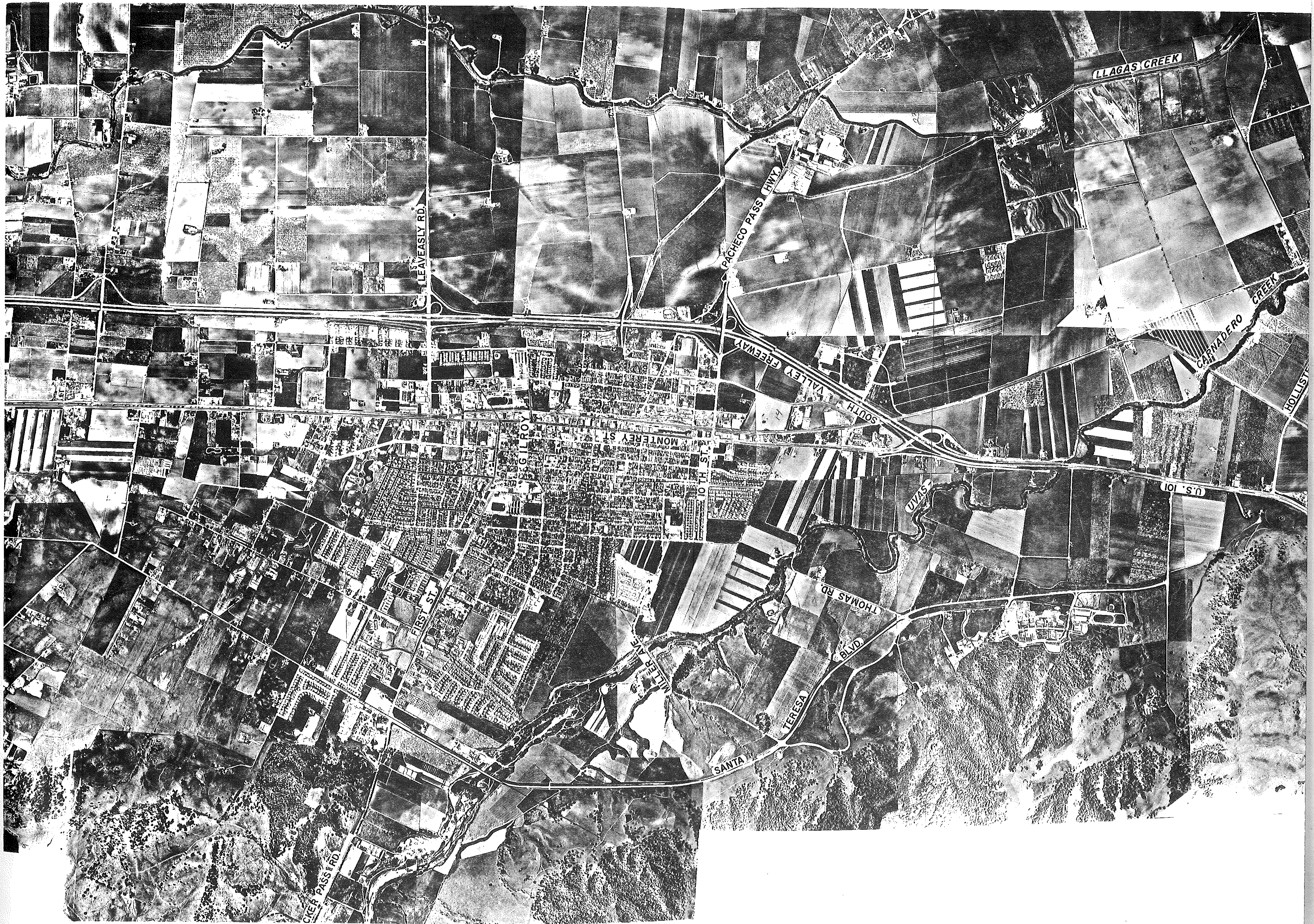


FIG. 3-6

UVAS-CARNADERO FLOOD PLAIN
SHOWING
CITY OF GILROY AND AGRICULTURAL LAND
1975

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY	PREPARED FOR
ANDERSON-NICHOLS & CO. INC. AND ANDREW H. TRICE, ECONOMIC CONSULTANT	SANTA CLARA VALLEY WATER DISTRICT AND SOUTH SANTA CLARA VALLEY WATER CONSERVATION DISTRICT


LLAGAS CREEK
LEAVEASLY RD.
PACHECO PASS HWY.
SOUTH VALLEY FREEWAY
CARNADERO CREEK
HOLLIST
GILROY
MONTEREY ST
10TH ST.
U.S. 101
UVAS
THOMAS RD
FIRST ST.
MILLER AVE
SANTA TERESA BLVD.
CKER PASS RD.

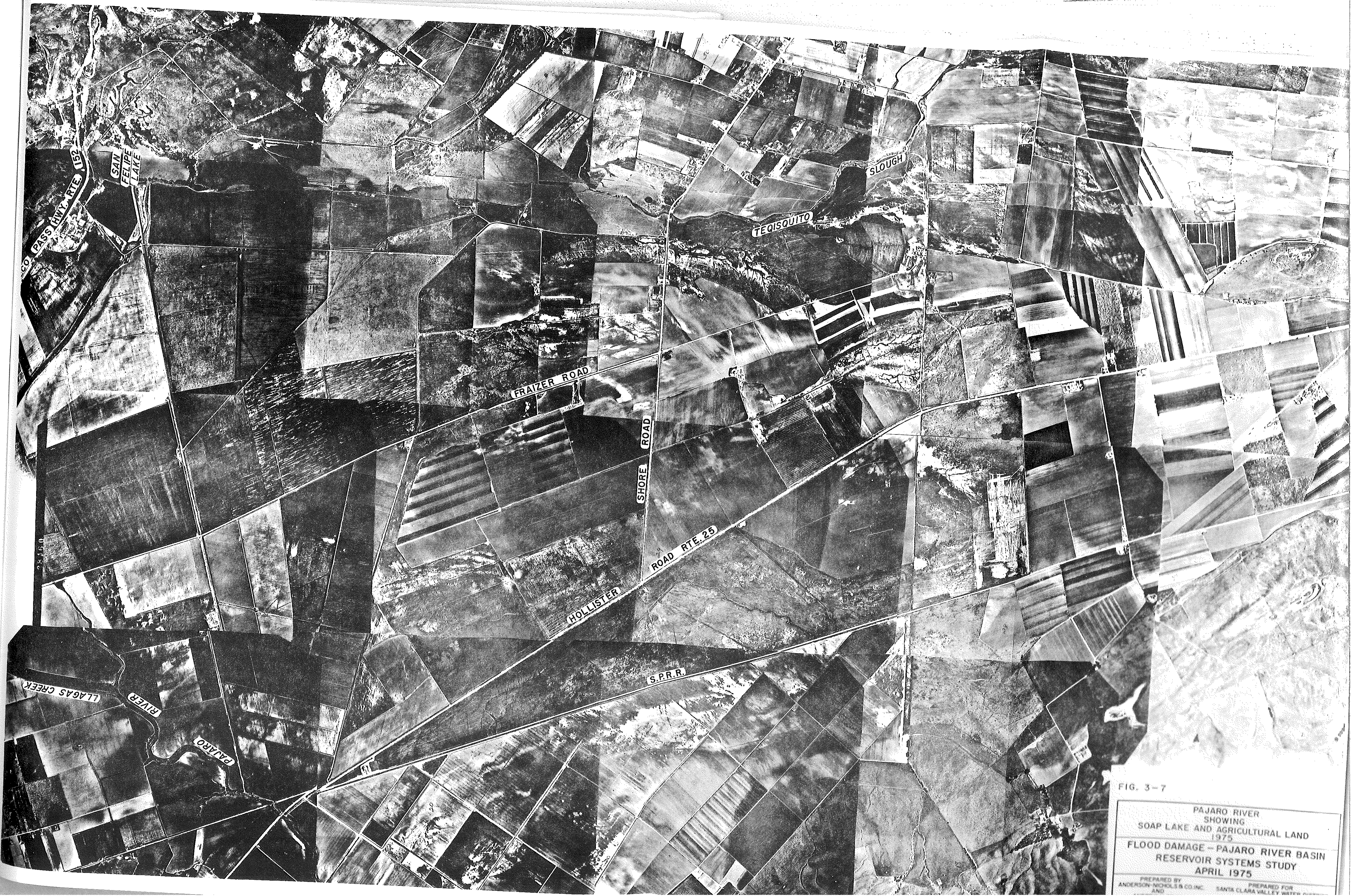


FIG. 3-7

PAJARO RIVER
SHOWING
SOAP LAKE AND AGRICULTURAL LAND
1975

FLOOD DAMAGE – PAJARO RIVER BASIN
RESERVOIR SYSTEMS STUDY
APRIL 1975

PREPARED BY
ANDERSON-NICHOLS & CO.INC.
AND

PREPARED FOR
SANTA CLARA VALLEY WATER DIST

Table 3-20
Flood Damage, $1,000
Reaches I, II and III
$1,000 Dollars

	S.P.F.	100-Year	50-Year	25-Year	12-Year
Row Crops	$ 3,249	$ 2,572	$ 1,601	$ 618	$ 125
Orchards	111	77	49	9	2
Roads, etc.	198	185	173	124	27
Residential	-	-	-	-	-
Commercial	-	-	-	-	-
Industrial	-	-	-	-	-
Public	-	-	-	-	-
Total	$ 3,558	$ 2,834	$ 1,823	$ 751	$ 154

Reaches IV, V and VI

	S.P.F.	100-Year	50-Year	25-Year	12-Year
Row Crops	$ 874	$ 583	$ 205	$ 141	$ 10
Orchards	11	5	2	1	1
Roads, etc.	242	211	192	28	10
Residential	1,493	708	211	103	2
Commercial	727	472	180	120	1
Industrial	902	679	199	155	30
Public	326	139	26	0	0
Total	$ 4,575	$ 2,797	$ 1,015	$ 548	$ 54

Reach VII

	S.P.F.	100-Year	50-Year	25-Year	12-Year
Row Crops	$ 21	$ 17	$ 8	$ 3	$ 0
Orchard	20	15	4	1	0
Roads, etc.	249	222	90	46	15
Residential	40	35	8	0	0
Commercial	13	11	2	0	0
Industrial	56	43	14	6	0
Total	$ 399	$ 343	$ 126	$ 56	$ 15

As prepared by economist - hydrologist

Evaluation of Corps' Estimates

It has been found that the Corps' 1975 study was incomplete in several respects. Indicative of the damage values not included are damages to streets and roads. Damage estimates appear low in several instances and in some cases do not follow a discernible pattern which reflects differing flood conditions or levels. There appears to have been no reconciliation of current findings with historical flood damages. This latter despite the requirement in the "Evaluations of Economic Benefits for Flood Control and Water Resources Planning" - (Fed. Reg. Aug. 15, 1974) which states: "The basis for the determinations of existing damage shall be losses actually sustained in historical floods."

When the 1965 report of the Corps was reviewed, it was found that damages were largely agricultural in contrast to the non-agricultural emphasis in the 1975 study. It is believed non-agricultural damages may have been understated when flood damage data were being collected after floods in 1955, 1958 and 1963. The report's emphasis on agricultural damages in the past suggests that current agricultural flood damage estimates are low in the light of the acres currently under production.

When the 1965 (February, 1964) flood estimates are adjusted to January 1975 for inflation and real changes, average annual damages without and with project are substantially greater than the estimates prepared in 1975. If original damages are adjusted in line with Corps' procedures at Watsonville on the Lower Pajaro the adjusted figures are even greater. These greater values are obtained even though the basic data probably understate damages.

Effects of Revised Damage Estimates

An attempt has been made to develop a set of damage values for agricultural crops, for residential areas, for commercial, industrial and public areas which reflect different levels of flood flows with different levels of flooding. These have been used in conjunction with revised acreage estimates and flood frequency estimates to secure a set of values for use with the HEC-5C Program. These results have been summarized in the paragraphs and tables which follow.

Average Annual Damages, Without Escalation for Future Growth

Average annual damages were computed for three areas and for several major types of land use. These figures are presented here, beginning with Reaches I, II and III, the lowest part of the floodplain, moving upstream to Reaches IV, V and VI and, finally, to Reach VII above Santa Teresa Expressway.

Table 3-21
Average Annual Damage
(1975 Dollars)
Uvas-Carnadero Creek
Damage Reach I, II, III
(Indexed at Uvas-Carnadero Mouth)

Damage Category	Existing Condition	With Hayes Valley Reservoir	Damage Reduction
Row Crop	$ 87,950	$ 18,310	$ 69,640
Orchard	2,400	410	1,990
Highways and Other	9,930	2,790	7,140
Total	$100,280	$ 21,520	$ 78,770

Table 3-22
Average Annual Damage
(1975 Dollars)
Uvas-Carnadero Creek
Damage Reach IV, V, VI
(Indexed at U. S. Highway 101)

Damage Category	Existing Condition	With Hayes Valley Reservoir	Damage Reduction
Row Crop	$ 17,510	$ 3,070	$ 14,440
Orchard	170	30	140
Highway & Other	7,420	1,040	6,380
Residential	21,230	3,120	18,110
Commercial	14,170	2,280	11,890
Industrial	19,980	4,020	15,960
Public	3,640	410	3,230
Total	$ 84,110	$13,980	$ 70,150

Table 3-23
Average Annual Damage
(1975 Dollars)
Uvas-Carnadero Creek
Damage Reach VII
(Indexed at Hecker Pass Road)

Damage Category	Existing Condition	With Hayes Valley Reservoir	Damage Reduction
Row Crop	$ 470	$ 50	$ 410
Orchard	340	30	300
Highway & Other	6,780	1,270	5,500
Residential	660	50	610
Commercial	200	20	190
Industrial	1,070	130	940
Total	$ 9,510	$1,550	$ 7,950

In combination, the flood reduction benefits of the Hayes Valley Project are as follows:

Table 3-24
Damage Reduction
Combined Effects By Land Use
Annual Damages

	Total Reduction		%
Row Crops	$ 84,490	-	53.9
Orchard	2,430	-	1.5
Highway & Other	19,020	-	12.1
Residential	18,720	-	11.9
Commercial	12,080	-	7.7
Industrial	16,900	-	10.8
Public	3,230	-	2.1
	$156,870		100.0

As can be seen, row crops account for almost 54% of the project benefits included in this illustrative calculation. No other category approaches this level of importance although highways and other, residential and industrial, each account for 10% or more of project benefits.

Reference to damage categories in the three tables indicates a possible imbalance in coverage in the three sub-areas. It is believed that a more detailed analysis would add categories and damages to each sub-area and give a somewhat different distribution of flood damage prevention emphasis. In no case is it expected that row crops will cease to be the major beneficiary.

From these data it appears that total flood control benefits from the Hayes Valley project, when specific items are added, could reach $400,000 to $500,000 in annual benefits. These values are exclusive of any benefit associated with Chesbro Reservoir and the flood control effects of Hayes Valley in that connection.

CONCLUSIONS AND RECOMMENDATIONS

There is a very serious flood problem in the Pajaro River Basin and the Hayes Valley Project reduces the damage potential beyond those cited in the 1975 analysis by the Corps.

1. Results of computer (HEC-2) backwater studies showed that significant levee overtopping would begin to occur in the City of Gilroy and neighboring areas at a flow of 7,000 cfs. This is one of the major differences between the finding of this study and those of the Corps presented to the Citizens Advisory Committee in January, 1975.

2. The overtopping will occur at a number of locations one of which would pose an immediate danger to new homes and construction including a high school costing in excess of $9 million. But more important, it could result in the loss of lives through a levee failure such as that described in the findings of our consultant.

3. Flood damages in the reach from Hecker Pass to the base of Uvas Dam was omitted from the Corps' evaluation of damage. This is Reach VII, as designated in this report, and during the 100-year flood, approximately 950 acres and about 70 homes would be inundated. Omitted from the Corps' study of Reach 1 was the floodplain area of Soap Lake located in San Benito County. This floodplain area ranges between 200 and 8,000 acres depending on the severity of the flood. It is regularly flooded (see frontispiece) and a significant reduction in flooded area could be effected if the proposed Hayes Valley Reservoir is constructed.

4. The study of agricultural damage showed that, because of South Santa Clara Valley's conversion from orchards to row crops, up to 7,000 acres of agricultural land are vulnerable to even greater damages than that registered in the 1955 flood. Agricultural damage, alone, totaled $1.5 million in 1955 dollars.

These row crops receive early winter topsoil preparation, fertilization and herbicide treatment which, except for harvesting, represents the major cost of farming these crops. In addition, because of this preparation, there is a high probability of the loss of much of the topsoil due to erosion, transport and gullying. Thus, there is a distinct possibility that the successive year's crops would not be produced or might be marginal.

5. The proposed Hayes Valley Reservoir would, in addition to the damage reduction in the Upper Pajaro River (Gilroy area), also provide $85,000 average annual damage reduction in the Lower Pajaro River Basin at Watsonville and surrounding areas.

6. The results of these analyses culminated in the preparation of a new flood damage curve which when integrated over the life of the proposed project shows that estimated flood control benefits for the proposed offstream storage facility at Hayes Valley would be as follows:

AVERAGE ANNUAL DAMAGE REDUCTION AND OTHER BENEFITS OF HAYES VALLEY RESERVOIR PROJECT

Upper Pajaro Basin (Gilroy and neighboring areas)	$ 157,000	
Lower Pajaro Basin (Watsonville and surrounding areas)	83,000	
Subtotal (Damage Reduction under existing conditions)		240,000
Locational Benefits (Corps' Report to Advisory Committee)	47,000	
Floodproof Benefits (Corps' Report to Advisory Committee)	88,000	
Subtotal (Future Benefits)		135,000
Elimination of Raising Chesbro Reservoir (PL566 Project - 5/75)		248,000
TOTAL FLOOD CONTROL BENEFITS		623,000
WATER SUPPLY AND RECREATION BENEFITS (1975 Corps' Data)		2,367,000
TOTAL BENEFITS		$2,990,000

7. With the Corps' estimate of $2.73 million for the average annual cost of construction of Hayes Valley Reservoir, the Hayes Valley Reservoir Project benefit cost ratio is about 1.1 to 1. This calculation does not consider benefits such as anadramous fishery enhancement, onstream recreation benefits, and San Felipe terminal storage for South Valley distribution.

The Corps should undertake further studies, and it is recommended that the following elements be addressed:

1. Historic changes, updated to 1975 levels be utilized as basis to calibrate new damage estimates.

2. Include as "damages" the extent to which areas not actually inundated by smaller floods are adversely affected due to restricted access during floods.

3. Use flood damage values for each land use that reflects differences in water depths.

4. Reevaluate future benefits, in the light of existing damages, to ascertain benefits, particularly those in the Lower Pajaro Basin in and about Watsonville.

5. And, finally, consideration should be given to potential damage to new construction now under way and particularly the catastrophic impact of a levee failure or overtopping. It is also recommended that any extension of the study embrace all of the elements typically investigated in a flood control study. These include:

bridge replacement savings
bank protection expense avoided
intensification benefits
reduction of business losses benefits
reduction in emergency expenditures

As items somewhat peculiar to the area, consideration should be given to the interruption of traffic on Highway 101 and on the Southern Pacific Railroad line which runs through the most flood-prone area. Both of these major traffic facilities were out of service in the 1955 flood and would probably be out of service if not destroyed under 100-year and SPF conditions.